Research Article

The effects of digital animation technology on the academic achievement and spatial perception of middle school students

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Abstract: This study aimed at determining the effects of digital animation technology on students' academic achievements and spatial perceptions within the scope of the "Journey to History" unit of the social studies course. In addition, the sub-goals included revealing whether there was a relationship between academic success and spatial perception and whether academic success was a predictor of spatial perception. This research was conducted with a quasi-experimental design with a pretest/posttest control group. The sample consisted of a total of 82 students (EG1=30, EG2=24, CG=28) studying in a secondary school in Türkiye. Research data were collected through the academic achievement test and the spatial perception scale. It was determined that there was no statistically significant difference in the pretest academic achievement at the level of all groups, but there was a significant difference in the posttest in favor of the experimental group. In addition, a positive development was detected in the spatial perception of the students in the experimental group towards animation. It was found that there was a positive correlation between the posttest scores of the experimental groups and the spatial perception scale administered after the posttest. In addition, the posttest of the experimental groups predicted the spatial perception scale applied with the posttest. As a result of the research, it was observed that the learning method with animation technology had a significant positive impact on students' academic achievement and their spatial perception.

1. INTRODUCTION

We witness that the art of animation is as old as primitive human societies, through the murals of the Chauvet Cave in the south of France, which was discovered by Jean-Marie Chauvet and his two friends on December 18, 1994, and was therefore named after its chief explorer (also known in French as Chauvet-Pont-d'Arc Cave). As a matter of fact, among the wall paintings of this cave, which is a reflection of the Paleolithic Age culture (it is thought to date back 33 thousand years), as seen in Figure 1, especially the eight-legged bison depiction proves to us how far back the perception of the movement dates back (Azéma, 2015).

In the process where animation has evolved from a simple moving image perception to today's technological evolution, the Praxinoscope, invented by French Professor Emile Reynaud in 1876, deserves great appreciation (Myrent, 1989). As shown in Figure 2, the Praxinoscope (Johnson, 2018) consisted of a box with a cylindrical structure fixed to a kind of shaft and

colored paper strips arranged in successive stages on its inner surface. When the cylinder was rotated, the rapidly moving images on the inner surface were reflected on a mirrored prism mounted on the shaft, and this cycle presented a magnificent visual feast for the audience looking at the prism (Wells, 1998).

Figure 1. *Depiction of an eight-legged bison reflecting the perception of movement in the Paleolithic Age.*
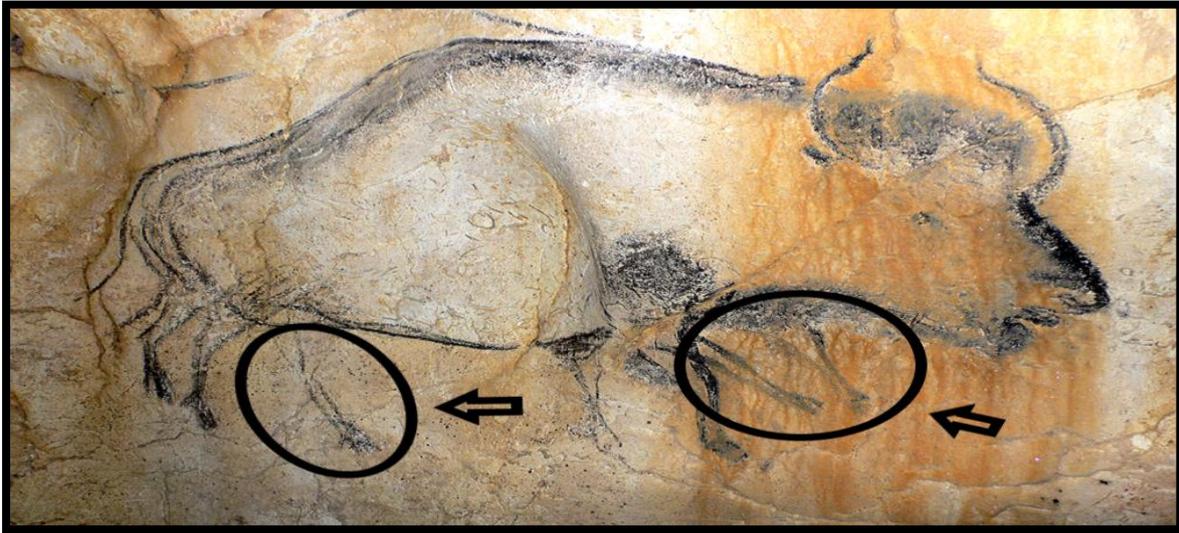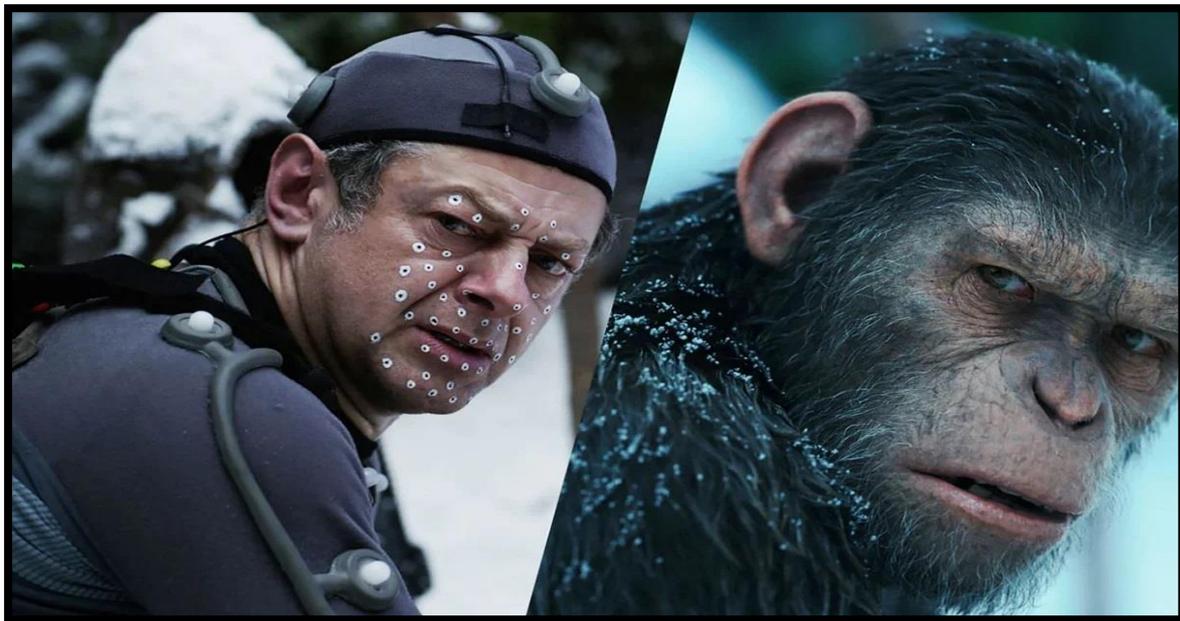

Figure 2. *Praxinoscope.*

Since primitive times, the curiosity of adding action to pictures has always aroused an urge for creation in the minds of human beings. Eventually, the moving painting technique took its place as a mechanical entertainment tool that managed to attract attention among the scientific and technological breakthroughs of the 20th century (Wells, 1998). Interestingly, what prevents animation from being recognized as an art form is its mechanical appearance during the technological breakthrough (it has been compared to a child's toy among the public). In fact, the fact that the first visuals prepared with the animation technique had a mechanical structure rather than an aesthetic one is a clear indication of this (Wells, 1998).

Words such as animation and animator are derived from the Latin word "animare," which means giving life. In the context of a video or film, animation can be described as the act of creating an artificial illusion of movement with motionless lines or shapes (Wells, 1998, p. 10). In its

most general sense, animation can be defined as the act of animating direct visual or both visual and auditory elements within the framework of a well-planned organizational structure in order to educate, entertain and give a message to groups of people. The basic elements of this animation can be a historical person, a fairy tale or fantasy hero, or any fruit or object. Digital animation is a type of current animation in which elements that appeal to many senses at the same time are prepared in a computer environment and delivered to the audience with the technological products offered by the electronic age (MoNE [Ministry of National Education], 2016). According to another definition of animation, "it is the process of arranging individual pictures or motionless objects in a way that gives a feeling of movement during the screening and transferring them to the film" (Kaba, 1992, p.1). Examples of digital animation include popular movies such as "Toy Story", "Spider-Man" and the "Incredibles" series. In addition, as shown in Figure 3, the digital effects used in the movie "Kingdom of the Planet of the Apes" reveal the latest stage of animation technology (Kamran, 2022).

Figure 3. *Digital effects prepared with advanced computer technology.*

Digital animation, which has built a deep-rooted and solid cultural structure over time, has not only become the apple of the eye of the film industry with the innovations that technology offers us day by day, but also has become more popular in fields such as computer game technologies, advertising industry and especially engineering and medicine in the education community. It has become the focus of attention in many fields. Various digital animation components that have a structure that can affect many basic skills can be used (such as: research, digital literacy, critical thinking, entrepreneurship, observation, communication, collaboration, using evidence, perception of space, media literacy, self-control, problem-solving, social participation, drawing and interpreting tables, graphs and diagrams, innovative thinking, time and perceiving chronology), especially in the process of adapting students to digital animation culture and using this culture as a teaching method.

Considering the fact that students have an extremely wide imagination, especially from pre-school education to primary and secondary school levels, it can be pointed out that digital animation activities have a structure that can respond to this intellectual ability of students (Husmann & O'Loughlin, 2018; Jannah & Bharata, 2020). The quality of education in the classroom depends on the strength of the interaction between teacher and student. It is essential to use materials that play some intermediary roles in this interaction process. In many recent studies, researchers have revealed how effective technology is as a teaching material, especially

at the primary and secondary school education level (Berney & Bétrancourt, 2016; Mansor *et al.*, 2018; Shreesha & Tyagi, 2018). Undoubtedly, advances in information technologies, which are the starting point of these teaching materials, have led to the development of various applications (animation, educational games, augmented reality, virtual reality, etc.) that help students better understand concepts and theories. Information technology applications have transformed learning methods into a digital/technological transformation by creating an active learning environment, thus finding a new development area within the framework of entertaining teaching approaches, supported by collaborative studies (Shreesha & Tyagi, 2018).

Within this development area, digital animation helps students understand complex concepts much more easily by increasing their conceptual perception skills, providing students with a deeper perception and multi-dimensional perspective than static pictures, increasing students' attention and motivation to the lesson, and helping students think analytically in the context of cause-and-effect relationships. It is possible to achieve many goals such as gaining skills, improving/improving students' ability to perceive time and space by combining them with concrete elements, responding to students' interests and wishes, ensuring students' active participation in lessons, and ensuring that students benefit from visual elements that they can internalize and concretize, thus averting a tendency towards mere memorisation.

For more effective and permanent learning, the multidimensional sensory structure of animation can be used. In this context, if the in-school functionality of animation can be transformed into a sustainable material by education centers, an innovative teaching method that both offers us the latest opportunities of technology and contributes to effective learning processes will be designed. Educators can use the magical charm of animated films to help students familiarize themselves with different animation techniques and develop their creative thinking skills. Thus, students will be actively involved in the effective learning process with animation using ready-made technology (Siegle, 2014).

Likewise, thanks to animations, students can become a part of the event they watch and identify themselves with the heroes of the event. In this regard, it can be argued that animations are one of the most effective educational methods in that students gain experience by doing and having fun during their in-school education. Among the basic functions of animation in the education and training process (MNE, 2016):

i. Its emotional and social impact in terms of supporting children's development of social and cultural values and enabling them to express their imaginary/inner world,
ii. Its cognitive effect in terms of activating spatial memory in children and supporting children's visual discrimination skills,
iii. Psychomotor effect in terms of providing children with the ability to express their feelings, thoughts and wishes with physical movements,
iv. It can also be considered to have an impact on children's linguistic development in terms of supporting their thinking, speaking, listening and expression skills.

Digital animation and video technology, which has begun to play an increasingly important role with the introduction of smart boards into the classroom environment, has provided an extremely wide range of implementation opportunities in the field of education and training for various disciplines, vocational training and especially in-class activities. It can also be argued that animations, which offer us a complementary learning experience from visual movements to various numerical simulations, can compensate for the weaknesses of some education-training approaches and models with their renewable software and hardware technical structure (Xiao, 2013).

Considering the relationship between the spatial thinking skills, which are integral to the mental development processes of students, and animation technologies in terms of innovative education systematics is an essential requirement in today's technological ground. Spatial skills, which are the ability to visualize how any object, picture, photograph or image may appear

from different angles (Turgut *et al.*, 2017), are extremely important in terms of providing students with different perspectives. It is generally accepted that spatial thinking skills are also an important component of intellectual (mental) ability. All of the different activities such as mental rotation of objects, perception of horizontality and the position of simple figures within complex figures have been called spatial ability measures (Linn & Petersen, 1985).

In parallel with the explanations above, within this study's scope, it aimed to test the student's academic success through an experimental implementation towards digital animation and to reveal the relationship between this experimental implementation and their spatial perception. Because it is an undeniable fact that digital animation technology and spatial perception form a whole. As Odabaşı (2007) also stated: Visual intelligence is the ability to see and think multidimensionally. Individuals with high spatial skills learn by seeing and observing. Similarly, while logical intelligence is more oriented towards the algebraic field of mathematics (numbers and problems), individuals with developed visual intelligence like geometry operations and area problems more. Their sense of direction is developed, and their imagination is strong. They like to take a picture of an object or event, draw it or record it on camera. They enjoy watching movies, documentaries or visual presentations. They are successful in visualizing the image, details, and depths of a three-dimensional object and visualizing that object in their minds. They like creative activities according to their age (p. 85).

According to Saban (2005), a human being can perceive the visual and spatial world accurately, like a hunter, scout or guide, or apply different shapes to the impressions he gets from the outside world, like a decorator, architect or painter. This area of intelligence includes the ability of an individual to observe objectively, perceive and evaluate his environment and, accordingly, to graphically display the visual and spatial ideas he gets from the outside environment (p. 44). Thanks to our visual perception, we collect information about the properties and locations of objects and thus understand and interact with our environment (Smith & Kosslyn, 2014).

In today's information process, where technologically focused scientific developments are rapidly spreading and gaining a new global dimension, interdisciplinary relations and approaches are being shaped within the framework of new needs and new revision movements are needed. In this rapidly developing process, undoubtedly, the duties and responsibilities that fall on both social sciences and social studies, which have gained great momentum especially with the studies carried out in the last half quarter, are becoming remarkable. Indeed, this momentum that social studies has gained simultaneously, especially with the digital evolution process, places it in a more central position in education and training movements and prepares it for a structure that not only acquires but also offers digital opportunities. In fact, both the teaching material developed in this research process and many digitally focused social studies education studies can be shown as evidence of this situation.

Social studies is in an intense relationship with the disciplines of social sciences within an interdisciplinary and holistic framework. The structural feature of social studies places it at the very center of digital transformation and gives it a great mission and vision. Indeed, the process of raising good and responsible citizens, which is among the basic goals of social studies, creates the necessity of having some innovations required by the digital revolution and constantly following technological developments and changes. The most concrete example of this is the concepts such as "Digital Citizenship, Digital Literacy, Media Literacy, Digital Competence" and the "Science, Technology and Society" learning area, which are included in both the current curriculum and textbooks. The material (animation) applied in this research process is directly related to both the learning area and the textbooks in terms of scope, achievements and goals. Indeed, with this research, the connection and importance of social studies with digital formation is also revealed very clearly. In order to have a say in the developing and changing world of education, it is undeniable that educational models suitable for the innovations brought by the age should be designed and that original digital formations, as in this research process, should come to the fore under the roof of social studies education.

It is observed that educational research on animation technology (Akaydın & Kaya, 2018; Baglama *et al.*, 2022; Özaydın, 2020; Özçakır & Çakıroğlu, 2022; Sel, 2022; Wolfe *et al.*, 2021) has gained increasing intensity in recent years. Animation and video technologies, which were previously intensively applied especially in the fields of medicine and visual arts, are now being used directly in educational sciences, and this has been linked to a visible process.

The study aimed to determine the effect of digital animation technology, an essential instrument of digital media, on students' academic success and spatial perception within the scope of the "Journey to History" unit of the social studies course. In addition, the sub-goals included revealing whether there was a relationship between academic success and spatial perception and whether academic success is a predictor of spatial perception. On the other hand, the digital animation applied in this research was designed and produced from scratch within the scope of a project, and the character designs and scenario belong to the researcher. In this context, it is thought to be important in terms of pioneering the introduction of digital animation technology into our education system as a suitable and useful course material.

In coordination with the purpose of the research, answers were sought to the following sub-problems:

1. Does the application of digital animation technology within the scope of the Journey to History unit have a significant impact on students' academic achievement and spatial perception?
2. Is there a correlation between academic success and spatial perception of the experimental and control group students?
3. Is the academic achievement of the experimental group students a significant predictor of their spatial perception?

2. METHOD

In this research, which was conducted with a quantitative research paradigm, a quasi-experimental design with a pretest/posttest control group, which is a type of experimental research, was applied. In addition, by posing sub-problems in the correlational research dimension, it was aimed to reveal whether there was any relationship between the subjects' academic success scores and their spatial perceptions. In the most general sense, experimental designs are used to test whether a put-forward opinion (application or method, etc.) has an effect on a dependent variable. When you want to reveal the cause-effect relationship between your dependent and independent variables, experimental designs are the ideal solution (Creswell, 2012). The most distinguishing feature of experimental designs is that we can make claims about the cause-and-effect relationship (Christensen *et al.*, 2014; Shadish *et al.*, 2002).

Fraenkel *et al.* (2012) stated this design as the best way to test a hypothesis in the context of a cause-and-effect relationship. Moreover, the most distinctive feature of this design is that researchers can manipulate the independent variable. The pretest-posttest control group design is similar to the posttest control group design, but a pretest is added here. Participants can be randomly assigned to two or more groups (such as fast readers and slow readers) and a pretest is given to these groups. Then, the procedure (experimental method) whose effect will be examined is applied, and the posttest is performed (Christensen *et al.*, 2014). Additionally, Bonate (2000) pointed out that analyzing posttest scores alone would be insufficient to reflect the results of the experimental treatment, therefore, it is important to apply pretest and posttest comparisons with a holistic approach.

2.1. Participants

The population consisted of students studying in the 6th-grade of secondary schools in Türkiye. The sample consisted of three branches of a secondary school in the 6th grade selected with the purposeful sampling method. In purposeful sampling, the researcher determined the characteristics of the population of interest, and then, identified individuals who fit the

necessary characteristics (Christensen *et al.*, 2014). Consequently, in order to ensure that the academic success averages and the number of students from the three branches included in this research were as close to each other as possible, purposeful sampling was employed.

In the course of the study, two experimental groups were established (hereafter referred to as "nexperiment1" and "nexperiment2"). The process in these groups was managed by applying digital animation. The third group, hereafter referred to as "ncontrol", served as the control group. In this group, the process was included, but not implemented. Demographic information of the experimental groups and the control group of the study is shown in Table 1.

Table 1. *Distribution of demographic information regarding experimental groups and control group.*

Groups	Branches	Gender	Frequency (*f*)	Percentage (%)
Experimental Group [1]	(Branch 6-I)	Female	17	57
		Male	13	43
Experimental Group [2]	(Branch 6-A)	Female	14	58
		Male	10	42
Control Group [1]	(Branch 6-E)	Female	14	50
		Male	14	50
Total			82	

In Table 1, Experimental Group1 [6-I branch] consisted of a total of 30 students (17 female students; 13 male students), Experimental Group2 [6-A branch] consisted of a total of 24 students (14 female students; 10 male students); The Control Group [6-E branch] consisted of a total of 28 students (14 female students; 14 male students).

2.2. Equivalence of Experimental and Control Groups

Before the implementation, pretest scores were compared to determine the equivalence of the groups (experiments-control). However, before comparing the scores, the groups' central tendency measures (mean, 5% trimmed mean, median) and central distribution measures (skewness, kurtosis) were also taken together with normality tests and histogram graphs. The normality of the distributions of the data (suitability for parametric testing) was determined by examining the line graph (Normal Q-Q Plots), scatter graph (Detrended Normal Q-Q Plots) and box-plot.

It was observed that there was no deviation in the central tendency measures of each group, the data within the groups took very close values to each other, and the central distribution measures took values between "-1.96 and +1.96", which is the acceptance range of each group. When the (*p*) values of the Shapiro-Wilk Tests were examined, it was observed that the values of all branches were greater than ".05" and there was no difference between them and the normal distribution. According to these results, the distributions were normal. In normality tests, the *p* value is expected to be greater than ".05". Since the suitability of the parametric test was observed after normality was ensured, as a result of the "One-Way ANOVA" conducted to determine the equivalence of the experimental and control groups, it was seen that there was no significant difference between the group averages and that all branches were equivalent/equal groups to each other. Table 2 shows the results of one-way ANOVA.

Table 2. *One-way anova results regarding the equivalence of groups according to the pretest.*

Pretest					
	Sum of Squares	*df*	Mean Squares	*F*	*p*
Between Groups	139.044	2	69.522		
Within Groups	28353.505	79	358.905	.194	.824
Total	28492.549	81			

In Table 2; between the pretest averages of the groups ($\overline{X}_{6-I}$ = 52.98, *SD* = 21.40), ($\overline{X}_{6-E}$ = 51.07, *SD* = 17.38), ($\overline{X}_{6-A}$ = 54.31, *SD* = 17.34) there is no statistically significant difference [$F(81)$ = .194, *p* > .05]. As a result, it was determined that all groups (branches) were equivalent to each other before the implementation.

2.3. Data Collection Tools

The data of the research was collected with the coordinated use of two different types of data collection tools. For the quasi-experimental design, the effect of animation technology (material) on students' academic achievement was tested with the multiple-choice "My History and Me" academic achievement test prepared by the researcher. The achievement test, consisting of a total of 18 questions, was prepared according to the multiple choice and 4-option answer criteria. The lowest score that could be obtained from each question in the achievement test was 5.5 points, while the highest score was 99 points. Students' perceptions of animation technology were determined through the "Spatial Perception Scale for Digital Animation", which was also developed by the researcher. The "Spatial Perception Scale for Digital Animation" consisted of 6 factors and a total of 23 items, prepared according to the five-point Likert type (from *Strongly Disagree* [1] to *Strongly Agree* [5]). First Factor (Awareness Factor, 8 items), Second Factor (Comparison Factor, 4 items), Third Factor (Negative Thought Factor, 3 items), Fourth Factor (Educational Factor, 3 items), Fifth factor (Orientation Factor, 3 items), Sixth Factor (Interest-Sympathy Factor, 2 items). Both of the aforementioned measurement tools (achievement test and scale) were actively published on the national thesis platform, with their validity and reliability proven within the scope of the doctoral thesis.

During the development of the achievement test, a question pool was created within the scope of the "Journey to History" unit [This unit is included in the 6th grade secondary school curriculum in Türkiye]. Following the completion of the requisite analyses (i.e. item difficulty, item discrimination, internal consistency [Cronbach Alpha], content validity), the questions were administered to the students as a pretest and posttest. Furthermore, after the necessary analyses for the scale (Validity, Reliability, EFA [Exploratory Factor Analysis], Principal Components Analysis, CFA [Confirmatory Factor Analysis]) were made, the scale was administered to the students in conjunction with the achievement test following the pilot implementation.

2.4. Analysis of Data

In this research, which was conducted with a quantitative approach, the analysis of the data was carried out using SPSS26 and EXCEL2016 software. Descriptive and predictive analyses (One-Way Analysis of Variance [One-Way ANOVA], One-Way Multivariate Analysis of Variance [One-Way MANOVA], Spearman Rank Difference Correlation, Simple Linear Regression) are presented to the reader in detail and in-depth with tables.

2.5. Implementation Process for Experimental and Control Groups

After determining the experimental and control groups, firstly "My History and Me Academic Success Test" and "Digital Animation for Spatial Perception Scale" were administered to all groups on the same day as a pretest implementation. When the scores obtained from the pretests of the groups were compared, it was revealed that all groups had equal success averages. After the equality between the groups was seen, a schedule was prepared for each group in cooperation with the teachers, including the date and time of the lesson, which topic would be covered that day (which state and cultural developments), important points to be emphasized in the lesson, and from which minute of the forty-minute lesson period the digital animation would be shown to the students (See Appendix 2/ Only the first week is shown.). The process of applying the research to all groups lasted a total of four weeks, three hours per week for each branch, but in order to demonstrate the effectiveness of digital animation technology in a more efficient way, an "additional time" was planned to cover one more lesson hour (40 minutes) in

line with the dedication of the course teachers. Accordingly, the same content was carried out with both the experimental and control groups in accordance with the schedule; the experimental groups were shown the last fifteen minutes of the second lesson on the days when there were double lessons for four weeks (In order to use the time efficiently and manage the process correctly, the first lessons in the double lesson hours were not shown digital animations) and in the single lessons, the last fifteen minutes were shown digital animations, and the entire animation was shown in the last lesson planned as an extra time, and the process was completed as a general review. In the control group, unlike the experimental groups, only digital animation was not given for four weeks, a general review was made in the extra time lesson (repetition of important points) and apart from this, the course process was carried out in all groups adhering to the same curriculum. In the week when the extra time was used (5th week), the academic achievement test and the spatial perception scale were applied to all groups simultaneously on the same day as a posttest, and the process was completed.

2.6. Validity and Reliability

The achievement test was created as a result of expert review, which was one of the strategies used to ensure content validity, by submitting it to the review of 11 experts in total, 4 from the field of social studies education, 2 from the field of history education, and 5 teachers who taught social studies in public schools (Christensen *et al.*, 2014). The content validity index (CVI) for the data obtained from the experts was accepted as ".59" (Karagöz, 2019, p. 104), and since no question that did not provide this score range was detected, the 30-question "My History and Me" academic success test took its final form before the analysis. After the content validity index calculation, two different secondary schools were selected for the pilot implementation through convenience sampling and a 30-question achievement test was applied to two branches of the 7th grades of the schools, covering a total of 87 students. Before proceeding with item difficulty and discrimination analysis, the internal consistency (Cronbach Alpha) of the achievement test was calculated and found to be $\alpha = .83$. The results of item difficulty and discrimination calculations are shown in Table 3.

Table 3 shows the decision results of academic achievement test questions according to item difficulty and discrimination indexes. Red colour indicates that the item it belongs to must be discarded, purple colour indicates that the item can be used after a correction/revision study, green colour indicates that the item is a good item but still requires editing, and colourless items indicate that the item can be used as is without any need for correction.

The item difficulty index takes values between 0 and 1, and the difficulty index close to 1 indicates the ease of the question, and being close to 0 indicates the difficulty of the question (Soylu *et al.*, 2020, p. 276). Item discrimination index (r_{jx}) is an analysis method aimed at revealing the extent to which questions discriminate between those who know and those who do not know the trait to be measured. Item loadings take values between "-1 and +1". Questions with an item discrimination index of ".19 and below" should be removed from the measurement tool, and questions between ".20 and .29" should either be removed from the measurement tool or used after being corrected (Bolat & Karamustafaoğlu, 2019, p. 138; Saraç, 2018, p. 421). In addition, ScorePak®, if the index is "above .30", indicates item discrimination as "good"; A score "between .10 and .30" is considered "medium"; a score "below .10" is considered "poor" (www.washington.edu).

Reference ranges for item difficulty and discrimination indices obtained from different sources are shown in Table 4 (Akdağ, 2022) and Table 5 (Escudero *et al.*, 2000, p. 5).

Table 3. *Academic achievement test item analysis on the entire sample.*

Item ID	Item Difficulty Index (p_j)	Decision	Item Discrimination Index (r_{jx})	Decision	Variance	Std. Deviation
1	.59	normal	.29	must be corrected	.24	.49
2	.66	normal	.41	perfect	.23	.48
3	.62	normal	.51	perfect	.23	.48
4	.47	normal	.40	perfect	.25	.50
5	.67	normal	.38	good	.22	.47
6	.52	normal	.47	perfect	.25	.50
7	.46	normal	.43	perfect	.25	.50
8	.60	normal	.44	perfect	.24	.49
9	.62	normal	.47	perfect	.24	.49
10	.52	normal	.53	perfect	.25	.50
11	.57	normal	.32	good	.24	.49
12	.47	normal	.55	perfect	.25	.50
13	.45	normal	.32	good	.25	.50
14	.34	normal	.26	must be corrected	.22	.47
15	.58	normal	.48	perfect	.24	.49
16	.38	normal	.57	perfect	.24	.49
17	.39	normal	.52	perfect	.24	.49
18	.37	normal	.34	good	.23	.48
19	.47	normal	.47	perfect	.25	.50
20	.23	difficult	.23	must be corrected	.18	.42
21	.48	normal	.37	good	.25	.50
22	.56	normal	.27	must be corrected	.25	.50
23	.56	normal	.42	perfect	.25	.50
24	.58	normal	.51	perfect	.24	.49
25	.38	normal	.24	must be corrected	.24	.49
26	.59	normal	.41	perfect	.24	.49
27	.51	normal	.48	perfect	.25	.50
28	.47	normal	.49	perfect	.25	.50
29	.78	easy	.19	low, remove	.17	.42
30	.56	normal	.24	must be corrected	.25	.50

Table 4. *Item difficulty and discrimination reference ranges.*

Item Difficulty Index (p_j)	Decision
.00 - .29	Difficult Question
.30 - .69	Normal Question
.70 - 1.00	Easy Question

Item Discrimination Index (r_{jx})	Decision
< 0	Item (Question) is Discarded
.00 - .19	Weak Item (Discarded)
.20 - .29	Item is Corrected and Taken
.30 - .39	Good Item (Corrected and Taken)
≥ .40	Very Good Item (Used)

Table 5. *Item discrimination reference ranges.*

Discrimination Index	Quality	Recommendation/Decision
> .39	Excellent	Keep
.30 - .39	Good	Improvement - development can be done
.20 - .29	Average	Need to be checked - Inspected
.00 - .20	Poor	Remove or review thoroughly
< - .01	Very Bad	Absolutely remove

After the item removal/extraction process, the "My History and Me" academic achievement test consisted of a total of 18 questions, including items/questions: "2", "3", "4", "6", "7", "8", "9", "10", "12", "15", "16", "17", "19", "23", "24", "26", "27", "28". In addition, the Cronbach Alpha coefficient for the internal consistency of the achievement test, which took its final form, was found to be ".82".

Before EFA, Cronbach Alpha (α) coefficient was calculated for the internal consistency of the items and found to be "$\alpha = .89$". Then, as a result of the Kaiser-Meyer-Olkin (K-M-O) test, which is a method used to test the adequacy of the sample size for EFA, the coefficient was found to be ".90". It was stated that the closer the K-M-O value is to "1", the better it is, and the lower it is unacceptable below ".50" [excellent at .90, very good at .80, mediocre at .70 and .60, and bad at .50] (Tavşancıl, 2018, p. 51). In addition, if this test cannot be performed, the sample size should be at least 5 or even 10 times the number of variables (items) (Tavşancıl, 2018, p. 51). Since the sufficient sample coefficient was reached as a result of the K-M-O test, another suitability test, Bartlett's Sphericity Test, was performed (whether the data is sufficient for EFA). Bartlett's Test examines the existence of the relationship between variables (items) based on correlation analysis. It provides information about the adequacy of the correlation between variables. This value is required to be less than .05 (significant/meaningful) in the 95% confidence interval (Aksu *et al.*, 2017, p. 47). Accordingly, as a result of the Bartlett Sphericity Test, [Chi-Square (χ^2) = 4409.597, *p* = .000] was found and since there was a significant difference at the *p* < .05 significance level, EFA analysis was carried out.

In the analysis of the draft scale form, the item eigenvalue was primarily taken as "1", the cut-off point for the item loading value as ".30", and the coefficients as ".10" for the detection of items showing overlapping item properties. As Tavşancıl (2018) also stated, it should be taken into consideration that the items do not fall into more than one factor (overlapping status) and there should be at least a ".10" difference between the criterion factor loadings (p. 50). In addition, the "varimax" rotation option, which is the most commonly used rotation type for orthogonal factor solutions, was preferred in the rotation process (Karagöz, 2019, p. 674; Özdamar, 2017, p. 149; Pallant, 2020, p. 202). Finally, the principal components were selected for the item extraction process preference.

The anti-image (.xa) correlation coefficient, which is a factor in whether an item is included in the scale, must be greater than ".50" (Can, 2017, p. 326; Özdamar, 2017, p. 148). Accordingly, the anti-image correlation table was examined and it was observed that the coefficient values for the largest and smallest items (M/Item) were as follows; "M21 = .953a" and "M18 (Reverse Item) = .636a", respectively. Another method used to determine the number of factors is the line graph, in other words, the scree plot. When the scree plot was examined regarding how many factors the scale form consists of, it was seen that the slope became a straight line at the end of the 6th factor (starting from the 7th Factor) in the first stage. However, since overlapping items were detected in the Rotated Component Matrix table, item extraction was performed starting from the item with the least difference in loading values (less than .10). According to the item extraction process, items M21, M25, M10, M20, M12 and M9 were removed from the scale form, respectively. The "Spatial Perception Scale for Digital Animation", which finally took its shape after EFA, consists of 6 factors/dimensions and a total of 24 items. Regarding

the scale; Total "α = .85" (1st Factor = .81; 2nd Factor = .70; 3rd Factor = .62; 4th Factor = .63; 5th Factor = .55; 6th Factor = .78), K-M-O coefficient was ".86", and the Bartlett Test of Sphericity result was found to be (χ^2 = 3140.661, p = .000). Item coefficients for EFA are shown in Table 6 (Items are marked with the letter M).

Table 6. *Spatial perception scale for digital animation EFA results.*

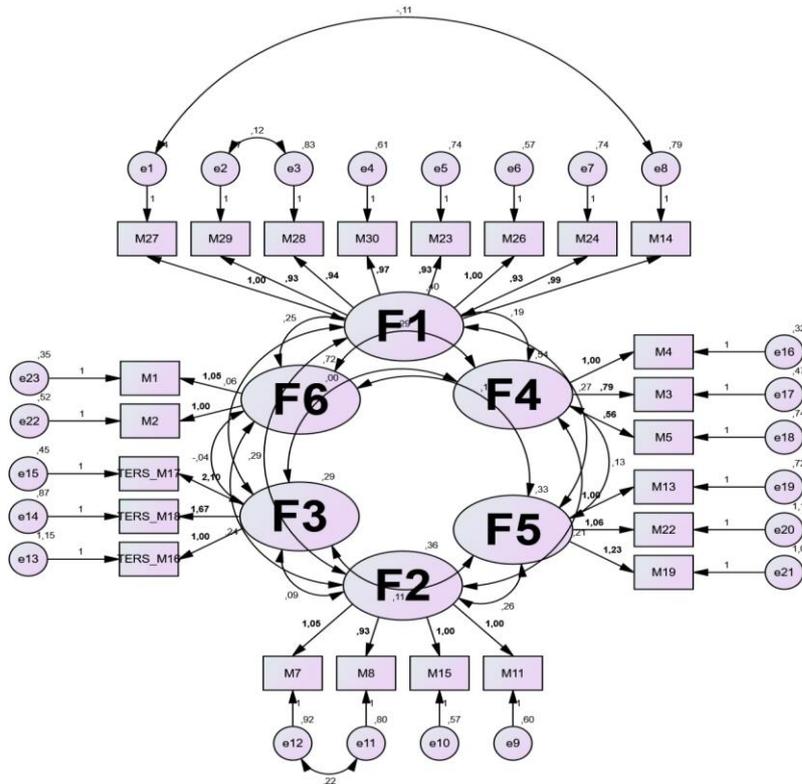| Item	Communalities (Variance Explained by Factors)	Rotated Factor Coefficients					
		1. Factor	2. Factor	3. Factor	4. Factor	5. Factor	6. Factor
M27	.55	.73					
M29	.53	.69					
M28	.45	.65					
M30	.46	.62					
M23	.42	.60					
M26	.46	.58					
M24	.39	.55					
M14	.37	.44					
M7	.57		.71				
M8	.55		.71				
M15	.47		.57				
M11	.46		.57				
M17*	.72			.82			
M18*	.76			.75			
M16*	.61			.58			
M6*	.49			.51			
M4	.72				.81		
M3	.67				.79		
M5	.44				.55		
M13	.49					60	
M22	.47					.56	
M19	.48					.56	
M1	.80						.83
M2	.78						.83
Eigenvalue Total	13.12	5.87	2.18	1.59	1.33	1.15	1.00
Total Variance Explained (%)	54.68	15.18	9.96	8.02	7.76	6.89	6.86

*Negative/reversed items

The accuracy of the structure obtained as a result of AFA was tested by creating a path diagram via CFA and AMOS. The fit indices for the scale are shown in Table 7 and the model (path analysis) is shown in Figure 4.

Table 7. *Model fit indices reference values.*

Fit Indexes	Perfect Match	Acceptable Compliance	Mismatch	Coefficient	Result
		Reference Values			
CMIN/DF	≤ .3	≤ .5	.5	1.84	Perfect
SRMR	≤ .05	≤ .08	> .08	.05	Perfect
RMR	≤ .05	≤ .08	> .08	.06	Acceptable
GFI	≥ .90	≥ .85	< .85	.94	Perfect
AGFI	≥ .90	≥ .85	< .85	.92	Perfect
NFI	≥ .95	≥ .90	< .90	.88	Mismatch
RFI	≥ .95	≥ .90	< .90	.85	Mismatch
IFI	≥ .95	≥ .90	< .90	.94	Acceptable
TLI	≥ .95	≥ .90	< .90	.93	Acceptable
CFI	≥ .97	≥ .95	< .95	.94	Mismatch
RMSEA	≤ .05	.05 ≤ RMSEA ≤ .09	> .10	.04	Perfect

Table 7 shows that after measuring the model fit indexes demonstrated as a result of the Confirmatory Factor Analysis (CFA), the data obtained provide the reference intervals to a large extent in reflecting the model (See Figure 4) and is compatible with the factors.

Figure 4. *Path diagram for structural equation model.*

(Note: The letter "M" indicates items and the letter "F" indicates factors. In addition, items written in "TERS M17, M18, and M16" are used in the sense of reverse)

After Confirmatory Factor Analysis, Spatial Perception Scale for Digital Animation consisted of 6 factors/dimensions and a total of 23 items. The Cronbach Alpha coefficient of the scale was measured as ".85". Cronbach's Alpha values for each factor:

1st Factor = .81; 2nd Factor = .70; 3rd Factor = .69; 4th Factor = .63; 5th Factor = .55; 6th

Factor = .78 was calculated, K-M-O coefficient was found to be ".86", and the Bartlett Sphericity Test result was found to be ($\chi^2 = 3064.578$, $p = .000$).

Regarding the number of items constituting the factor, it is stated that at least 3 variables are needed for variables (items) that are related to each other to be labeled as a factor (Karagöz, 2019, p. 771). However, when different sources are scanned, Aksu *et al.* (2017) state that as a general principle, rotated factors with 2 or less variables should be interpreted carefully and that a factor with 2 variables can be considered reliable only when there is a high correlation between the variables and a very low correlation with other variables ($r > .70$) (p. 5), which is evidence that a factor can consist of less than 3 items. In addition, as an example of 2-item factors, the study by Muck *et al.* (2007) in which each factor of the 5-factor structure in the scale consisted of 2 items; The 2-item Insomnia Severity Index (ISI) scale development and validity studies conducted by Kraepelien *et al.* (2021); Studies conducted on this subject by Marsh *et al.* (2008, pp. 187-189) can be shown. In line with these explanations, when the item loadings of Factor 6, which had 2 variables (items), were examined, it could be argued that there was no problem in labeling them as a factor since they were greater than the ".70" coefficient (M1 = .83, M2 = .83).

2.6. Material (Animation)

The material (animation) applied in the experimental process of the research was carried out as a service procurement within the scope of the scientific research project. The design of the material was completely original and new. All characters were created by drawing them one by one on paper and then transferred to the digital environment. The script of the material was written by the researcher and the researcher took an active role in all stages of the process, especially the character designs of the material. The animation, which lasted approximately 35 minutes, covered the political, cultural and religious structures of the Asian Hun State, the Göktürk State and the Uyghur State, the first Turkish States. The full animation, which is in high resolution and has a voiceover, can be accessed via the link below and some frames are shown in the Appendix 1. [https://www.youtube.com/watch?v=0mcZT8SVy7o&list=PLsFSZfp40L3cK8jE3mU-DahZwNzA3uSh7]

3. FINDINGS

In this section, the statistical findings regarding the sub-problems of the research (descriptive and predictive analyses; One-Way Analysis of Variance, One-Way Multivariate Analysis of Variance, Spearman Rank Difference Correlation, Simple Linear Regression) were discussed in a holistic approach and in-depth.

3.1. Findings Regarding the First Sub-Problem

When the one-way analysis of variance results for the posttest was examined in Table 8, there was a statistically significant difference between the posttest averages of the groups ($\overline{X}_{6-I} = 75$, $SD = 20$), ($\overline{X}_{6-E} = 63$, $SD = 26$), ($\overline{X}_{6-A} = 78$, $SD = 16$) and this difference had a medium-sized effect width [$F(81) = 3.629$, $p < .05$, $\eta^2 = .084$].

Table 8. *One-way variance analysis results for the posttest means of the groups.*

Posttest						
	Sum of Squares	*df*	*Mean Squares*	*F*	*p*	Difference
Between Groups	3353.545	2	1676.772			
Within Groups	36502.675	79	462.059	3.629	.031	6-A > 6-E
Total	39856.220	81				

In addition, as the variances were not distributed homogeneously as a result of the Levene test ($p < .05$), Welch and Brown-Forsythe tests, which are more powerful tests, were examined. In order to see which groups this significant difference exists between, Tamhane's T2, Dunnett's T3, Games-Howell, Dunnett's C tests, which are used for unequal variances among Post-Hoc tests, were examined (Can, 2017; Karagöz, 2019). As a result of all these tests, it was determined that there was a significant difference between the second experimental group (6-A) and the control group (6-E).

The mean scores of both the spatial perception scale applied with the pretest and the posttest were compared through "One-Way Multivariate Analysis of Variance" and the results are shown in Table 9.

Table 9. *One-way multivariate analysis of variance results for spatial perception scale scores.*

Dependent Variables	Groups (Branches)	n	$\overline{X}$	SD	df	F	p
Scale Applied with Pretest	6-I	28	3.97	.69			
	6-E	28	3.53	.65	3-76	3.315	.042
	6-A	23	3.63	.66			
Scale Applied with Posttest	6-I	28	4.12	.56			
	6-E	28	3.63	.75	3-76	5.207	.008
	6-A	23	4.14	.65			

In the Box test, Pillai's Trace test was taken into account since there was a significant difference between the covariance matrices ($p = .035$, $p < .05$). Levene's test showed that the variances were homogeneous for the spatial perception scale applied with the pretest ($p = .833$, $p > .05$) and for the spatial perception scale with the posttest ($p = .197$, $p > .05$). According to the measurements made before and after the implementation of animation technology, it was determined that there was a positive development in the perception of students in the experimental group towards animation [$F_{(\text{Hypothesis df-Error df/4-152})} = 3.831$, $p < .05$, Pillais' $= .183$, partial $\eta^2 = .092$].

As a result of the Tukey test, which was preferred because the homogeneity of variances was ensured, it was determined that all differences were only among the experimental groups and the control group. This proves that the implementation works on experimental groups.

3.2. Findings Regarding the Second Sub-Problem

There was no relationship between the control group's average scores on the spatial perception scale administered with both the pretest and posttest. For this reason, the "Spearman Rank Difference Correlation" table for the control group was not added:

Spatial perception scale applied with the pretest ($r = .221$, $p > .05$);

Spatial perception scale applied with the posttest ($r = -.024$, $p > .05$).

In the experimental groups, no relationship was observed between the pretest and the spatial perception scale ($r = .195$, $p > .05$), but a relationship was observed between the posttest and the spatial perception scale ($r = .337$, $p < .05$).

Table 10. *Posttest for experimental groups and spearman rank difference correlation analysis results for the spatial perception scale administered with the posttest.*

		Correlations		
			Posttest	Mean_Scale_2
		Correlation Coefficient	1.000	.337
Spearman's rho	Posttest	p (2-tailed)	.	.016
		N	51	51

In Table 10, as a result of the "Spearman Rank Difference Correlation" analysis, which was conducted to reveal whether there was a relationship between the posttest mean scores of the students in the experimental groups, and the spatial perception scale applied with the posttest, it was observed that there was a positive and significant relationship. In other words, the change in the posttest mean scores of the experimental groups can explain 11% of the change in the mean scores of the spatial perception scale applied with the posttest [$r = .337$, $r^2 = .114$].

3.3. Findings Regarding the Third Sub-Problem

When Table 11 is examined, a significant relationship was found as a result of the simple linear regression analysis regarding whether academic success predicts spatial perception: [$r = .337$, $r^2 = .114$] and [$F_{(1-49)} = 6.283$, $p = .016$, $p < .05$]. The posttest mean scores of the experimental group students explain approximately 11% of the spatial perception scale applied with the posttest. The significance test of the coefficient of the predictive variable based on the regression equation shows that the posttest is a significant predictor. Simply put, academic achievement is a predictor of spatial perception.

Table 11. *Simple linear regression analysis model results for the posttest of the experimental groups and the spatial perception scale administered with the posttest.*

	Coefficients[a]				
Model	Unstandardized Coefficients		Standardized Coefficients	*t*	*p*
	B	Std. Error	Beta		
1 (Constant)	3.310	.336		9.847	.000
Posttest	.011	.004	.337	2.507	.016

a. Dependent Variable: Mean_Scale_2

4. DISCUSSION and CONCLUSION

In this section, the results obtained from the research findings are discussed based on the literature. Accordingly, regarding the effect of digital animation technology on increasing success and critical thinking skills, Ritonga *et al.* (2020) on the "effectiveness of problem-based video animation in teaching" can be cited as an example in line with the results obtained in this research. Just as emphasized in this research process, teachers can more easily explain mechanisms or concepts related to processes in lessons thanks to digital animation. Animations that can be repeated and stopped according to students' needs provide a more flexible environment that supports learning activities. In addition, it has been revealed that digital animation can attract students' attention in the classroom and provide an environment in which they can clarify their ideas more easily and understand concepts more easily. Thus, it was stated that students supply gains in long-term memory retention from video animation. In an extremely similar manner, in the experimental implementation process of this research, the feature of animation technology based on audio-visual elements was utilized, thanks to digital animation, abstract concepts were concretized through various visuals, and a way was followed to increase students' attention to the lesson without getting bored.

The results of the spatial perception scale applied with both the pretest and posttest regarding the spatial perception of the students in the experimental groups showed that there was a positive development in the students' perceptions of animation in the spatial perception scale applied with the posttest. This result is also important in terms of emphasizing the concepts of perception of space, location analysis, perception of time and chronology, which have been frequently emphasized in the field of social studies education in recent years and are included in the current curriculum. Although these concepts are in all fields of education, they are especially popular in studies conducted in the fields of geography, history and social studies (Beatty, 2016; Biyane, 2007; Goldstein, 2008).

As a matter of fact, within the scope of this research, the importance of the adaptation of digital animation technologies to the education system and their positive effects on students' spatial perception development have been revealed through various analyses. Again, in this research process, students' spatial perceptions were supported with various space patterns, so that students could perceive the concepts of time and space more easily through animated films, and a more permanent learning was achieved by concretizing the concepts with images.

The research results show that the senses of vision, hearing, smell, touch and taste are effective on learning (Kaya, 2006). If evaluated in the light of the explanation, in a social studies course with history content where animation technology has the opportunity to be applied, both the senses of vision and hearing, which are stated to affect the learning processes of students, are activated in a coordinated manner and students are provided with the opportunity to integrate and concretize their imagination (mechanisms) with a historical subject. Of course, it is observed that educational studies on animation have started to increase considerably in the literature (Albayrak, 2020; Aslan-Efe, 2015; Büyük, 2022; Ceylan & Seçken, 2019; Kılıç, 2022; Uysal, 2020; Ünal, 2020), and it is also observed that each study and the materials designed within these studies make significant positive contributions to the academic success of students.

Finally, the research results regarding the relationship and prediction between the effect of digital animation technology on students' academic achievement and their spatial perception showed that while there was no relationship or prediction before the experimental implementation, there was a positive increase between the academic success scores and spatial perception of the experimental group students after the experimental procedure. It has been determined that academic success predicts spatial perception.

Yani *et al*. (2018) revealed the relationship between spatial intelligence, spatial skills and geography skills of students in primary, secondary and high school levels. It was determined that spatial intelligence tended to increase from primary school to high school, but spatial skills and geography skills tended to decrease. The study emphasized that spatial thinking had an important role in geography learning as it formed the basis of various skills such as visualization of maps, graphs, pictures and diagrams, and it was revealed that spatial intelligence had a positive effect on the development of geography skills. Similarly, as reflected in the results of this research, there was a positive relationship between students' academic achievements and spatial perceptions.

4.1. Recommendations

1. Both in this research process and in other studies, the effects of digital animation and similar technologies on students' academic success have been revealed. In this context, it is recommended that educational coordinations organize various activities that will provide financial support in order to pave the way for such technological developments that increase academic success and encourage researchers.

2. It is recommended that researchers apply new types of digital animation materials applied in the 6th grade of secondary school with original designs in different learning areas or lessons, and that these applications are not limited to only the secondary school level but also be studied in new studies for primary and high school levels.

3. Among the results of the study, there was a positive relationship between academic success and spatial perception, and it was determined that academic success predicted spatial perception. Based on these results, it is recommended that researchers examine the effects and relationship of spatial perception in different learning areas, courses and subjects in new studies.

4. Regarding the reporting of achievement tests; in studies with more than one experimental and control group (e.g. two experimental and two control groups), the absence of a significant difference ($p > .05$) in one of the control groups may lead to the One-Way ANOVA result being insignificant for all experimental groups. It is recommended that researchers act with the

awareness that reaching a non-significant difference in comparisons of more than one experimental and control group may be due to this reason.

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The author declares no conflict of interest. This research study complies with research publishing ethics. The scientific and legal responsibility for manuscripts published in IJATE belongs to the author. **Ethics Committee Number**: Atatürk University, Social Sciences and Humanities Ethics Committee, 22.04.2022-05/37.

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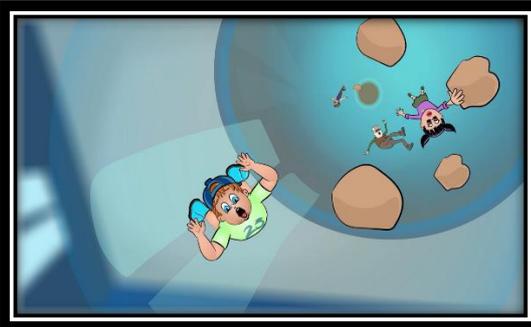
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APPENDIX

1. *Visuals of the animation applied to the experimental group.*

2. *Implementation schedule for experimental and control groups (Only the first week is shown).*

IMPLEMENTATION PROCESS CHART				
WEEK		**First Week**		
		EXPERIMENTAL GROUPS		**CONTROL GROUP**
DAY		**6-I**	**6-A**	**6-E**
MONDAY	Class Hours	09:35 – 10:15 10:20 – 11:00 (a.m.)	Free day	Free day
	Topic to be Covered	*[1]		
	Underline	**[2]		
	Animation Watching Time	10:45 a.m. (15 minutes)		
TUESDAY	Class Hours	09:35 – 10:15 (a.m.)	08:00 – 08:40 08:45 – 09:25 (a.m.)	Free day
	Topic to be Covered	***[3]	*[1]	
	Underline	****[4]	**[2]	
	Animation Watching Time	10:00 a.m. (15 minutes)	09:10 a.m. (15 minutes)	
WEDNESDAY	Class Hours	Free day	Free day	11:50 – 12:30 12:35 – 13:15 (a.m.)
	Topic to be Covered			*[1]
	Underline			**[2]
	Animation Watching Time			
THURSDAY NO IMPLEMENTATION.				
FRIDAY	Class Hours	Free day	12:35 – 13:15 (a.m.)	11:05 – 11:45 (a.m.)
	Topic to be Covered		***[3]	***[3]
	Underline		****[4]	****[4]
	Animation Watching Time		13:00 a.m. (15 minutes)	

*[1]	Central Asia; geographical location and climate characteristics, cultural structure, belief system.
**[2]	Show Anatolia and Central Asia on the map, steppe culture (explain the climate structure in comparison with Anatolia), nomadic/horse-riding culture (tent culture), summer pastures and winter pastures.
***[3]	Characteristics of Central Asia (Complete the topic), Pazyryk Carpet, Man in the Golden Dress, Belief in Sky God, customs, state administration-rulers, the role of the woman in administration.
****[4]	Yuğ (funeral ceremony), kurgan (tomb structure), kurultay/toy (Congress), khan-khan-khagan (male ruler), hatun (the sovereign's wife/female ruler), kut belief (passing of the throne from father to son).