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## THE EFFECT OF TEACHING "THE STATES OF MATTER AND HEAT" TOPIC WITH EDUCATIONAL GAMES CORROBORATED WITH SCIENTIFIC NARRATIVES ON STUDENTS' ACADEMIC ACHIEVEMENT AND SCIENCE ATTITUDES

**Seyda OZDEMIR**

Science Teacher, Ataturk Secondary School, Susuz/Kars, Turkey, [seydaxozdemir01@gmail.com](mailto:seydaxozdemir01@gmail.com)  
ORCID:0009 0007 4486 7123

**Emine Hatun DIKEN**

Assoc. Prof. Dr., Kafkas University Dede Korkut Faculty of Education, Kars, Turkey, [hatundiken06@gmail.com](mailto:hatundiken06@gmail.com)  
ORCID: 0000 0003 3922 2535

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### ABSTRACT

The study seeks to assess the effect of instructing the "States of Matter and Heat" topic, through educational games corroborated with scientific narratives, on the academic performance and attitudes of 6th-grade students towards science course, along with the students' perceptions of this instruction technique. A mixed-methods design was used for the research objectives. Forty-eight sixth-grade students from two different secondary schools in a district of Kars, Turkey, were included in the study. Research data were collected using the "States of Matter and Heat Aptitude Test", "The Scale of Attitudes toward the Science Course" and the "Survey on Teaching Science with Educational Games Corroborated by Scientific Narratives". Prior to the intervention, the Aptitude Test and the Scale were administered as a pre-test to students from two different secondary schools. The topic was then taught to the students from one middle school through a direct instruction technique. The students from the other middle school were instructed through educational games corroborated by scientific narratives. The research was implemented over a four week period. Following the intervention, the Aptitude Test and the Scale were administered to students as a post-test. Students who were taught through educational games corroborated by scientific narratives were also asked to provide written feedback on the teaching technique. Quantitative data were analyzed with the Independent Samples t-Test, Wilcoxon Signed Rank Test, and Mann Whitney U Test, while qualitative data underwent content analysis. The study revealed that instructing the topic through educational games corroborated by scientific narratives enhanced students' academic performance and attitudes towards science. Students indicated that this instructional approach facilitated their comprehension, heightened their interest in the course, allowed them to engage with the topic enjoyably, and rendered the session stimulating.

**Keywords:** Scientific narrative, educational game, matter and heat, academic achievement, attitude

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**Corresponded Author:** Assoc. Prof. Dr., Emine Hatun Diken, Kafkas University, [hatundiken06@gmail.com](mailto:hatundiken06@gmail.com)

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## INTRODUCTION

Science is an essential discipline that instructs us on how to address and resolve various challenges, that we face in our daily lives, through a scientific perspective (Dadaylı & Pekbal, 2021). In science classes, which frequently encompass challenging topics, students may struggle to comprehend the abstract concepts presented in depth (Dumlu Güler, 2011; Kavşut et al., 2011). This may lead students to disengage from the course, cultivate unfavorable attitudes towards it; causing them to retreat, and lose their interest (Karamustafaoğlu et al., 2018; Kılıç & Karamustafaoğlu, 2020). Employing educational games serves as a method to assist primary and secondary school students in mastering fundamental skills addressed in science course curricula, solidifying abstract concepts, dispelling biases regarding the science course, enhancing their interest and motivation in the topic taught, facilitating active participation through experiential learning, cultivating favorable attitudes toward the course, capturing their attention, promoting enjoyable learning, retaining newly acquired knowledge, and encouraging constructive engagement in the educational process (Altunay, 2004; Çavuş et al., 2011; Şahin & Demir, 2023; Ün Açıkgöz, 2014; Önen et al., 2012). Educational games significantly contribute to the instruction of science (Heidemann & Hewitt, 2010; Tok, 2009; Yıldırım et al., 2023). Educational games encompass a series of activities contributing all phases of the educational process, facilitating autonomous learning and enabling students to independently uncover knowledge (Atay, 2018; Yıldırım, 2015; Kılıç & Karamustafaoğlu, 2020). Educational games not only offer students an engaging learning environment but also facilitate a more enjoyable and accessible learning process. They stimulate students' curiosity and desire to explore, augment their motivation to learn, and promote constructive cognitive processes by alleviating anxiety levels (Atay, 2018; Braude & Corey, 2006; Kavşut et al., 2011). Educational games used in science classes are important and effective pedagogical instruments (Atasoy & Ertürk, 2008). Corroborating educational games with scientific narratives is an exceptionally effective strategy improving the students' comprehension of science curriculum content, internalize scientific concepts, address challenges encountered in science classes using these concepts, augment their interest and curiosity in science, improve their understanding of the topic, and render the course more productive, effective, and enjoyable (Coşkun et al., 2012; Yılmaz Korkut & Şaşmaz Ören, 2018; Tezel & Aksoy, 2020; Tezel & Karacalı, 2018; Yılmaz & Deniz Çeliker, 2022). Scientific narratives assist students in cultivating science literacy while enhancing their conceptual comprehension and academic performance (Akçay et al., 2014; Avraamidou & Osborne, 2009; Çakar, 2007). Scientific narratives, akin to educational games, are effectively employed in teaching science (Millar & Osborne, 1998; Tao, 2002; Özyay Köse & Yıldırım, 2020). When the literature is examined, the results of the studies show that educational games and scientific stories increase students' knowledge and attitudes, making learning easier and more fun. Therefore, the study seeks to assess the effect of instructing the "States of Matter and Heat" topic, to 6. grade students, through educational games corroborated with scientific narratives, on the academic performance and attitudes thereof towards science course, along with the students' perceptions of this instruction technique. This teaching approach seeks to facilitate students' comprehension of intricate science topics within the unit material. This technique is further expected to foster teaching experience for both teachers and students by rendering the topic more engaging and pleasant.

## **METHOD**

### **Study Design**

In the study, explanatory sequential design, one of the mixed design types, was used. In the explanatory sequential design, quantitative data are first collected and analyzed. Appropriate questions are developed for the qualitative data based on the analysis of the quantitative data. The results of both methods are then examined together and analyzed (Fraenkel et al., 2012). This quasi-experimental study employed a non-equivalent pre-test/post-test control group design for quantitative research purposes. Considering two distinct groups exhibiting analogous characteristics, this design requires the intervention group to be administered the scales, whereas the control group remains non-intervened, and then both groups are administered a post-test (Balıcı, 2010; Özmen & Karamustafaoglu, 2019). Furthermore a case study design was used for qualitative research. A case study is a design employed when substantial evidence pertains to a contemporary situation within its setting (Yıldırım & Şimşek, 2021; Yin, 1984).

### **Participants**

The sample comprised 48 sixth-grade students from two different secondary schools (22 students from one school and 26 students from the other) in a district of Kars province, Turkey, selected through convenience sampling. In convenience sampling, situations or people that are easy to reach and close to others are selected (Yıldırım & Şimşek, 2021).

### **Data Collection Tools**

Research data were collected using the "States of Matter and Heat Aptitude Test", "The Scale of Attitudes toward the Science Course" and the "Survey on Teaching Science with Educational Games Corroborated by Scientific Narratives".

#### ***States of Matter and Heat Aptitude Test***

The first data collection tool used in the study was the "States of Matter and Heat Aptitude Test". The aptitude test consists of 13 multiple-choice questions. The questions presented to the students in the aptitude test were sourced from "<https://cdn.eba.gov.tr/yardimcikaynaklar/2022/11/kt/6kt/fen/17.pdf>" and underwent validity and reliability assessments. The questions to be administered were selected based on the opinions of three science teachers. Three academics with experience in Physics then assessed the aptitude test questions to identify any inaccuracies or misconceptions. The aptitude test was administered to 6th-grade students after the revisions made by academics.

#### ***The Scale of Attitudes toward the Science Course***

The second data collection tool is "The Scale of Attitudes toward the Science Course" developed by Karabulut and Çetin (2018). The lowest and the highest possible scores on the five-point Likert-type scale with a factor loading greater than 0.300 and a Cronbach's alpha of 0.91 are 30 and 150, respectively. Approval was sought and granted by Karabulut and Çetin (2018) to use the scale in this research.

### ***Survey on Teaching Science with Educational Games Corroborated by Scientific Narratives***

The third data collection tool administered in this study was “Survey on Teaching Science with Educational Games Corroborated by Scientific Narratives”. This survey was developed by the authors. The questions were then reviewed by faculty members who had conducted studies on educational games corroborated by scientific narratives at two different universities. Some of the questions were revised based on feedback from faculty members.

The questions in the survey are as follows:

- 1- How satisfied were you with this instruction technique?
- 2- How confident are you that you learned the topic through this instruction technique?
- 3- Did you encounter any challenges while learning the topic through this instruction technique?
- 4- If you experienced any difficulties while learning the topic through this instruction technique, what did you do to overcome this problem?
- 5- What are your thoughts, feelings, and concerns about learning this lesson through this instruction technique?

### **Implementation Process of the Research**

Throughout the intervention, the authors opted to instruct the topic "State of Matter and Heat", which presents significant challenges for students due to its abstract and complex concepts, to 6th-grade students through the use of educational games corroborated with scientific narratives. The scientific narratives intended for classroom instruction were developed through the collaborative efforts of the authors as well as science and Turkish language instructors. The scientific narratives employed were "Matterland," focusing on states of matter and their particulate structure; "Density Island" addressing the proximity of particles in matter; "Master Thermo, the Sage of the Heat Kingdom" examining heat conduction and insulation and "The Energy Kingdom" exploring “Fuels”. Two academics with research experience in similar topics then assessed the scientific narratives to identify any inaccuracies or misconceptions. These academics reviewed the scientific narratives and made necessary corrections. Thereafter “Scientific Narratives on the "States of Matter and Heat" have been prepared for use in research.

"Master Thermo: The Sage of the Heat Kingdom" is presented below to serve as an illustrative example of the scientific narratives developed for the topic of "Heat Conduction and Thermal Insulation" within the "States of Matter and Heat" unit.

In a land far, far away, there lived a fascinating village where the heat changed every single day. In this village, heat was the determining factor in every circumstance. Reason being, thermal insulation and heat conduction were the cornerstones of this village. The villagers were all attempting to figure out how heat is conducted and how to insulate it. A story set in the village was as follows: The foremost scholar in this village was "Master Thermo, the Sage of the Heat Kingdom." Master Thermo was the best person to explain “Heat”. One day a group of villagers were asked by Master Thermo to take part in an entertaining experiment concerning thermal insulation and conduction. Under his smile, Master Thermo addressed the class, "Today, I'm going to teach you how heat moves.”

"First, let's take a trip!" A sense of curiosity and excitement washed over the class as they watched Master Termo. They started by making it to the village's heat conduction point. The transfer of heat between different states of matter was illustrated at this point. Master Termo was holding a metal rod in his hand. Then Master Termo addressed the class, "See, this rod has a hot end and a cool end. Now, use your hands to hold the metal's heated end". The students held the heated end of the metal rod. Upon further observation, Hakan and Lara noted that the opposite end of the rod was likewise becoming hot. "The heat here is changing!" Hakan yelled. Master Termo replied Hakan: "Indeed. The heat moved from the hot end of the rod to the cold end. Matter can transfer heat to one another through conduction. Metal particles transfer energy when they collide. The term for this process is referred to as heat conduction". Students thought, "Heat is rapidly transferred and spreads everywhere!" when they saw how fast heat is conducted through metal. Afterward, Master Termo and the students visited the thermal insulation point. Master Termo demonstrated the students a bottle with cotton covered with crystal glass, saying, "Now, let's learn how to preserve heat." Master Termo showed the students a bottle filled with hot water, wrapped in cotton. By touching the exterior of the bottle, the students were able to determine whether it was hot. The exterior of the bottle was cold. Lara: "Heat builds up inside the matter, as in this bottle, cotton prevents it to escape. Materials used for insulation also stop heat from escaping. This way, the hot water stays inside the bottle and doesn't cool down. So, it's crucial to use heat-preserving materials!" she said. Master Termo responded: "Exactly. Thermal insulation is very beneficial, particularly during the cold winter months. Insulation not only retains heat but also helps energy savings". Master Termo added: We can observe and confirm thermal insulation and heat conduction in the things we use every day. To illustrate this point, we typically use ceramic mugs for hot beverages rather than metal ones. This way we can avoid heat loss. Alternatively, we can save energy by keeping the cold air outside with heat-insulated windows." With Master Termo's helpful instruction, the students were able to regulate the power of heat, which made them very happy. From that day on, there was a marked improvement in the village's efficiency. Because the students in the village discovered that heat is not only transferable but also conserved. With this newfound knowledge of heat conduction and thermal insulation, the villagers continued their lives with a much greater awareness.

The educational games intended for classroom instruction were also developed through the collaborative work of the authors as well as science teachers. The educational games prepared were "Matter and Heat Hunt," which is related to the states of matter and its particulate structure; "Open the Box," which is related to the proximity of particles in matter; "Heat Explorers: A Matter and Heat Adventure" related to heat conduction and thermal insulation and "Word Hunt" related to the topic of "Fuels." Two academics with research experience in similar topics then reviewed the educational games. These academics reviewed the educational games and made necessary corrections.

The educational game "Matter and Heat Hunt", developed addressing the "States of Matter and Particulate Structure" topic of the "Matter and Heat" unit is presented below to serve as an illustrative example.

The Title of the Game: "Matter and Heat Hunt"

Materials to be Used for Playing the Game:

1. Cards Representing Different Types/States of Matter: Cards representing water, ice, steam, stone, air, oxygen, etc.
2. Heat Cards: Cards representing concepts such as hot, cold, heating, cooling, particles, and particle movements.
3. Timer
4. Notebook and a pen: For keeping notes.

**Game Rules:**

1. Prepare: The teacher prepares the matter and heat cards mentioned above. A brief description of the states of matter, heat, particles, and their movement, is printed on the reverse side of each card. Cards are placed in different parts of the classroom.
2. Formulating the Groups: Students are divided into groups of five.
3. The Game: Within a given time limit of ten minutes, each team attempts to locate the maximum number of cards. After collecting the cards related to the states of matter or heat, students should read each one and write a phrase based on the facts shown. For instance "Oxygen is a gaseous substance with lots of space between its particles" as well as "Ice is a solid substance with a cold temperature."
4. Scoring: Each group receives 1 point for each correct sentence. A group is required to return a card if they fail to present a reasonable phrase about it.
5. Time Limit: When time is up, the teacher collects the cards from all groups and counts the scores.
6. Bonus Questions: At the end of the game, the teacher allows each team to win more points by answering bonus questions. "What changes a liquid into a solid?" is an exemplary question in this regard.
7. Winner: The group with the highest score wins the title of "Matter and Heat Champion".

Following the Game: As a means of fostering classroom discourse, students can impart the knowledge acquired in the game to one another. When students have trouble grasping a concept, the teacher elaborates so that they can reinforce what they need to know.

The ethics committee approval in order to carry out the research and the interventions was sought from the university where one of the authors worked and the university's "Institute of Science Scientific Research Ethics Committee" granted the approval as per the third Committee Decree No: 66, dated February 19, 2025. The intervention phase started once the necessary approvals were communicated to the administrators of the two secondary schools that would host the study. The study was conducted throughout the 16-hour science classes. First, the "States of Matter and Heat Aptitude Test" and the "The Scale of Attitudes toward the Science Course" were administered as pre-tests to 6th-grade students from two different secondary schools, who were assigned into intervention and control groups. The topic titled "Matter and Heat" was taught to 26 students in the control group over a month period through direct instruction technique, whereas 22 students in the intervention group were instructed through educational games corroborated by scientific narratives. Students participated in the intervention phase of the study on a voluntary basis. The topic was instructed to the intervention group students via scientific narratives in the "Engage" Step of the 5E instructional model (Engage, Explore, Explain, Elaborate, Evaluate) whereas educational games were used in the "Elaborate" step. The science teacher, who was also one of

the authors of the study, read scientific narratives to the intervention group students throughout the weekly science class in the “Engage” Step of the 5E instructional model. She then posed intriguing questions, created discussions, and piqued the students' interest. In the next step called “Elaborate”, the teacher assigned the students to do educational gaming tasks related to the course. First, the educational games were introduced to the students, the rules of the games were thoroughly explained, and any aspects that the students did not grasp were reiterated. The teacher then instructed the students to play educational games to reinforce their learning, stimulate active engagement in the learning process, better understand topics in a pleasant setting, and collaborate. After teaching the topic with educational games and scientific narratives, students in the intervention group were administered the aptitude test and the scale as post-tests. Students in the control group, who were taught the topic through direct instruction technique, received an aptitude test and the scale as post-tests. Finally, survey forms were distributed to students in the intervention group, where the topic was instructed using educational games corroborated with scientific narratives. After the students in the intervention group filled out the questions on the survey with a pencil, the author recalled the survey forms. The author then checked whether the students had answered all the questions. Students who left some questions unanswered were reassigned to ensure they answered all of them. Thus, the intervention process of the research was completed.

### **Data Analysis**

Normality analysis was primarily used in the analysis of the research's quantitative data. Normality analysis allows us to determine which test type to use in data analysis. Based on the normality analysis results, if the data are normally distributed, parametric tests are used; if not, non-parametric tests are used. (Büyüköztürk, 2007). Non-parametric "Wilcoxon Signed Ranks" and "Mann Whitney U" tests, as well as the parametric "Independent Samples t-Test." The Independent Samples t-Test, a parametric analysis, assesses the significance of differences between two independent groups. When parametric tests fail to satisfy the assumptions, the Mann-Whitney U Test is employed. This test determines whether there is a significant difference between the scores of two independent groups (Büyüköztürk, 2007). The Wilcoxon Signed Rank Test tests the statistical significance between measurements of paired data (e.g. pre- and post intervention measurements) by considering the rank values and the direction of the differences (Fraenkel & Wallen, 2006; Büyüköztürk, 2007). The qualitative data of the study were analyzed using content analysis. The researcher meticulously examined and reread the students' written responses to the survey questions, confirming and establishing student viewpoints through analysis (Miles & Huberman, 1984). Comparable student replies were compiled, frequency values were assigned, and student opinions were systematically structured and interpreted for reader comprehension (Yıldırım & Şimşek, 2021).

### **FINDINGS**

To ascertain if a significant difference existed between the pre-test and post-test aptitude test scores of the 6th grade students (as these scores represent the quantitative findings of this study) the normal distribution of the data was examined. The Shapiro-Wilk Test was used for this purpose.

The normal distribution test findings for the pre-test and post-test administration of the aptitude test to the control and intervention groups are presented in Table 1.

**Table 1.** Normal Distribution Test Findings for the Pre-test and Post-test Administration of the Aptitude Test

Shapiro-Wilk Test				
Groups	Tests	Statistics	df	p
Experimental	Pre-test	.931	22	.130
	Post-test	.887	22	.017*
Control	Pre-test	.945	26	.179
	Post-test	.929	26	.075

\*p<0.05

Table 1 indicates that, owing to the restricted size of the control and intervention groups, the normality of the data distribution was evaluated using the Shapiro-Wilk Test (Pituch & Stevens, 2016). The pre-test aptitude test scores of the intervention group ( $W = .931, p > .05$ ) and the pre-test aptitude test scores of the control group ( $W = .945, p > .05$ ) exhibited a statistically normal distribution. Accordingly, a parametric Independent Samples t-Test was used to compare the pre-test aptitude test scores. Conversely, the post-test aptitude test scores of the intervention group ( $W = .887, p < .05$ ) did not meet the normal distribution assumption, whereas the post-test scores of the control group ( $W = .929, p > .05$ ) conformed to it. Therefore, post-test aptitude test scores were compared using the Mann-Whitney U test.

The results of the Independent Samples t-Test analysis, performed to ascertain if a significant difference existed between the pre-test scores of the aptitude test for the control and intervention groups, are presented in Table 2.

**Table 2.** The Results of the Independent Samples t-Test Analysis Performed for the Groups' Pre-test scores of the Aptitude Test

	Control Group		Intervention Group		t(46)	p
	M	SD	M	SD		
Pre-test	4.61	1.16	4.73	2.12	.231	.818

Table 2 indicates that there was no statistically significant difference between the mean pre-test aptitude test scores of the control group ( $M = 4.61, SD = 1.16$ ) and the intervention group ( $M = 4.73, SD = 2.12$ ) ( $t(46) = .231, p = .818$ ). In other words, both groups' pre-test aptitude test scores were equivalent.

The results of the Independent Samples t-Test analysis, performed to ascertain if a significant difference existed between the post-test scores of the aptitude test for the control and intervention groups, are presented in Table 3.

**Table 3.** The Results of the Mann-Whitney U Test Analysis Performed for the Groups' Post-test scores of the Aptitude Test

	Control Group		Intervention Group		U	Z	p
	SO	ST	SO	ST			
Post-test	13.52	351.50	37.48	824.50	.500	-5.971	.000*

\*p<0.01

Table 3 indicates that there was a statistically significant difference between the mean post-test aptitude test scores of the control group ( $M_{so} = 13.52$ ) and the intervention group ( $M_{so} = 37.48$ ) ( $U = .500, p = .000$ ). In other words, the post-test aptitude test scores of the intervention group were significantly higher than the control group's.

The Wilcoxon Signed Rank Test was used to compare the pre-test and post-test aptitude test scores of both groups. The results of the Wilcoxon Signed Rank Test, performed to ascertain if a significant difference existed between the pre-test and post-test scores of the aptitude test for the control group, are presented in Table 4.

**Table 4.** Wilcoxon Signed-Rank Test Results for the Aptitude Test Administered to the Control Group

Groups	n	Average Ranks	Sum of Ranks	Z	p
Negative Ranks	6	5.75	34.50	-3.165	.002*
Positive Ranks	17	14.21	241.50		
Equal Ranks	3				

\*p<0.05

Table 4 indicates that there was a statistically significant difference between the pre-test and post-test aptitude test scores of the control group ( $Z = -3.165$ ,  $p = .002$ ). Following the intervention, a decrease in the aptitude test scores was noted for 6 students, an improvement was noted for 17 students, and no change was observed for 3 students.

The results of the Wilcoxon Signed Rank Test, performed to ascertain if a significant difference existed between the pre-test and post-test scores of the aptitude test for the Intervention group, are presented in Table 5.

**Table 5.** Wilcoxon Signed-Rank Test Results for the Aptitude Test Administered to the Intervention Group

Groups	n	Average Ranks	Sum of Ranks (SoR)	Z	p
Negative Ranks	0	.00	0.00	-4.126	.000*
Positive Ranks	22	11.50	253.00		
Equal Ranks	0				

\*p<0.05

Table 5 indicates that there was a statistically significant difference between the pre-test and post-test aptitude test scores of the Intervention group ( $Z = -4.126$ ,  $p = .000$ ). It was determined that the post test aptitude test scores of the students in the intervention group ( $n = 22$ ) increased after the intervention.

A significant increase was observed in aptitude test scores for both groups. The increased aptitude test scores of all students in the intervention group demonstrate that educational games corroborated by scientific narratives positively influence students' academic performance.

It was analyzed whether or not there is a significant difference between the students' pre-test and post-test scores on the Scale of Attitudes toward the Science Course to determine the impact of teaching the unit using educational games corroborated with scientific narratives on students' attitudes toward science. Before this analysis, the Shapiro-Wilk test was used to check whether the data showed a normal distribution.

The results of the normality tests performed for the pre-test and post-test scores of the control and intervention groups on The Scale of Attitudes toward the Science Course are presented in Table 6.

**Table 6.** Normal Distribution Test Findings for the Pre-test and Post-test Administration of the Scale of Attitudes toward the Science Course

Groups	Tests	Shapiro-Wilk Test		
		Statistics	df	p
Experimental	Pre-test	.871	22	.008
	Post-test	.900	22	.029*
Control	Pre-test	.973	26	.709
	Post-test	.846	26	.001*

\*p<0.05

Table 6 indicates that, owing to the restricted size of the Intervention and Control groups, the normality of the data distribution was evaluated using the Shapiro-Wilk Test (Pituch & Stevens, 2016). The pre-test scores of the intervention group on the Scale of Attitudes toward the Science Course (W= .871, p>.05) and the pre-test scores of the control group on the Scale of Attitudes toward the Science Course (W = .973, p>.05) exhibited a statistically normal distribution. Therefore, the Independent Samples t-Test was used to compare the pre-test scores of the groups on the attitude scale.

The post-test scores of the intervention group on the attitude scale (W= .900, p<.05) and the post-test scores of the control group on the attitude scale (W = .846, p<.05) did not meet the normal distribution assumption. Therefore, the difference between the post-test scores of the groups on the attitude scale was analyzed using the Mann-Whitney U Test.

The results of the Independent Groups t-Test, which was conducted to determine whether there was a statistically significant difference between the pre-test scores of the groups on the attitude scale, are presented in Table 7.

**Table 7.** The Results of the Independent Samples t-Test Analysis Performed for the Groups' Pre-test scores on the Attitude Scale

	Control Group		Intervention Group		t(46)	p
	M	SD	M	SD		
Pre-test	57.35	9.75	46.27	8.53	-4,149	.001*

\*p< 0.05

Table 7 indicates that there was a statistically significant difference between the mean pre-test scores of the control group (M= 57.35, SD= 9.75) and the intervention group (M= 46.27, SD= 8.53) on the Attitude Scale (t(46) = -4.149, p=.001). This suggests that the two groups' attitudes toward science course were different before the intervention.

Due to a significant difference with regard to the groups' attitudes towards the science course at the beginning, it was deemed inappropriate to directly compare post-test scores. Instead the change in the attitudes between pre-test and post-test was assessed within each group. As the post-test scores did not exhibit a normal distribution, a Wilcoxon Signed Rank Test was used for comparison.

The results of the Wilcoxon Signed Rank Test, performed to ascertain if a significant difference existed between the pre-test and post-test scores on the Attitude Scale for the control group, are presented in Table 8.

**Table 8.** Wilcoxon Signed-Rank Test Results for the Attitude Scale Administered to the Control Group

Groups	n	Average Ranks	Sum of Ranks	Z	p
Negative Ranks	13	11.00	143.00	-525	.600
Positive Ranks	12	15.17	182.00		
Equal Ranks	1				

Table 8 indicates that there was a statistically significant difference between the pre-test and post-test scores of the control group on the Attitude Scale ( $Z = -0.525$ ,  $p = .600$ ). Following the intervention, a decrease in the attitude scale scores was noted for 13 students, an improvement was noted for 12 students, and no change was observed for 1 student.

The results of the Wilcoxon Signed Rank Test, performed to ascertain if a significant difference existed between the pre-test and post-test scores of the Intervention group on the Attitude Scale, are presented in Table 9.

**Table 9.** Wilcoxon Signed-Rank Test Results for the Attitude Scale Administered to the Intervention Group

Groups	n	Average Ranks	Sum of Ranks	Z	p
Negative Ranks	0	.00	0.00	-4.109	.000*
Positive Ranks	22	11.50	253.00		
Equal Ranks	0				

\* $p < 0.05$

Table 9 indicates that there was a statistically significant difference between the pre-test and post-test scores of the Intervention group on the Attitude Scale ( $Z = -4.109$ ,  $p = .000$ ). It was determined that the post test scores of all the students in the intervention group ( $n = 22$ ) on the Attitude Scale increased after the intervention.

The results indicate that, whereas the scores of the control group students on the Attitude Scale remained unchanged, all students in the intervention group exhibited an increase in their scores on the Attitude Scale. In other words, it is possible to conclude that instructing the topic through educational games corroborated by scientific narratives enhanced students' attitudes towards science course.

The views of the students and the frequencies identified as the qualitative findings of the study are demonstrated in the following tables. Relevant explanations are provided below the tables.

The student responses to the question “How satisfied were you with this instruction technique?” and the frequencies of the responses are shown in Table 10.

**Table 10.** Students’ Views on Whether the Teaching Technique Satisfied Students

Students’ Views	Definitely Not Satisfied	Not Satisfied	Somewhat Satisfied	Satisfied	Definitely Satisfied
Frequency (f)			1	6	14

Table 10 indicates that the instructional approach of using educational games corroborated with scientific narratives “somewhat satisfied” one student, “satisfied” six students, and definitely satisfied fourteen students.

The student responses to the question “How confident are you that you learned the topic through this instruction technique?” and the frequencies of the responses are shown in Table 11.

**Table 11.** Students' level of confidence in their learning of the unit with this instruction technique

Students' Views	Definitely Not Confident	Not Confident	Somewhat Confident	Confident	Definitely Confident
<b>Frequency (f)</b>			2	9	10

Table 11 indicates that 2 students were “somewhat confident”, 9 students were “confident” and 10 students were “definitely confident” with regard to their learning of the unit with the instructional approach of using educational games corroborated with scientific narratives.

The student responses to the question “Did you encounter any challenges while learning the topic through this instruction technique?” and the frequencies of the responses are shown in Table 12.

**Table 12.** Students' Views on whether they encountered any challenges while learning the topic through this instruction technique

Students' Views	Yes, encountered challenges	No, did not encounter any
<b>Frequency (f)</b>	9	11

Table 12 indicates that 9 students did not encounter any challenges while learning the unit with the instructional approach of using educational games corroborated with scientific narratives, whereas 11 students reported difficulties with regard to learning with this instructional approach.

The student responses to the question “If you experienced any difficulties while learning the topic through this instruction technique, what did you do to overcome this problem?” and the frequencies of the responses are shown in Table 13.

**Table 13.** Students' Views on What They Did to Overcome The Difficulties Experienced While Learning The Topic Through This Instruction Technique

Students' Views	Frequency (f)
I re-reviewed the unit many times	4
I solved questions related to the unit.	3
I listened carefully to my teacher.	2

Table 13 indicates that 4 students re-reviewed the unit many times, 3 students solved questions related to the unit and 2 students listened carefully to their teacher to overcome the difficulties experienced while learning the topic through the instructional approach of using educational games corroborated with scientific narratives.

The student responses to the question “What are your thoughts, feelings, and concerns about learning this lesson through this instruction technique?” and the frequencies of the responses are shown in Table 14.

**Table 14.** Students Views After Instruction

<b>The Students' Thoughts, Feelings, and Concerns</b>	<b>Frequency (f)</b>
I understood the unit very well.	13
My interest and focus in the course increased.	7
I had fun and learned as well.	6
It was exciting.	5
I learned new stuff.	3
The lesson was not boring.	3
It was a very successful learning experience.	2

Table 14 indicates that following the science courses where the unit was taught through the instructional approach of using educational games corroborated with scientific narratives, 13 students understood the unit very well, 7 students reported that their interest and focus in the science course increased, 6 students told that they had fun and learned the topic as well, 5 students found this instructional approach exciting, 3 students reported that they learned new stuff, 3 students told that they did not find the lesson boring and 2 students found this a very successful learning experience.

## **CONCLUSION and DISCUSSION**

The quantitative results of the study revealed that instructing the "States of Matter and Heat" topic through educational games corroborated with scientific narratives fostered the academic performance and attitudes of the students towards science course.

There are further studies in the literature that support these results.

Can (2010) reported that teaching the "Structure and Properties of Matter" topic to 8. Grade students with educational games; Bayat et al. (2014) and Korkmaz (2018) argued that teaching the same topic to 7. Grade students with educational games; Elgün and Kaya (2015) reported that teaching the "Our Planet Earth" topic to 4. Grade students with educational games; Gençer and Karamustafaoglu (2014) argued that teaching 'Electricity in Our Lives' topic to 7. grade students with educational games; Demircioğlu and Akdemir (2019) argued that teaching "States of Matter" topic to 9. grade students with educational games and Gürbüz (2019) reported that teaching "Propagation of Light" topic to 5. Grade students with educational games fostered their academic performance and attitudes towards science course. Furthermore, in the results of their studies, Yenice et al. (2019) found that teaching "Mystery of the Earth's Crust" topic to 5. Grade students with educational games; Yıldız and Şimşek (2020) found that teaching "Force and Motion" topic to 6. grade students with educational games; Dadaylı and Pekbay (2021) found that teaching "Measurement of Force and Friction" topic to 5. grade students with educational games; İnce and Çelikler (2021) found that teaching "Particulate Structure of Matter" to 6. grade students with educational games improved their academic performance, Yıldız and Şimşek (2022) found that teaching the units of "Circulatory System" and "Force and Motion" with educational games increased the academic success and retention of knowledge of sixth-grade students, while Yıldız (2023) found that teaching the subjects of "Distinctive Properties of Matter" and "Heat and Temperature" with educational games increased the attitudes of fifth-grade students towards science lessons. Çınar (2016) discovered that corroborating science classes with narratives concerning the history of science fostered both the academic performance and attitudes of seventh-grade students towards science courses. Tolğay (2018) concluded that teaching the "Electricity in Our Lives" topic with scientific narratives increased the academic performance of sixth-grade students. Moreover Coşkun et al. (2012)

found that teaching “Electricity in Our Lives” topic to 7. Grade students with educational games corroborated with scientific narratives improved their academic performance. Beker et al. (2022) reported that teaching “Force and Motion” topic to 6. Grade students with educational games corroborated with scientific narratives improved their academic performance and Tezel and Aksoy (2020) reported that teaching the “Periodic System” to 8. Grade students with educational games corroborated with scientific narratives improved their academic performance.

The qualitative results of the study revealed that teaching science topics to students using educational games corroborated with scientific narratives “definitely satisfied” or “satisfied” vast majority of students. Majority of the students were “definitely confident” and were “confident” with regard to their learning of the unit with this instructional approach. It was determined that the vast majority of students did not experience significant difficulties in learning the topic taught using this technique and students who experienced difficulties in this regard (if any) either re-reviewed the unit many times, solved questions related to the unit or listened carefully to their teacher to overcome any difficulties experienced. Following the science courses where the unit was taught through the instructional approach of using educational games corroborated with scientific narratives, students reported that they understood the unit very well, that their interest and focus in the science course increased, they had fun and learned the topic as well, they found this instructional approach exciting, they learned new stuff, they did not find the lesson boring and they found this a very successful learning experience.

There are other studies in the literature that identified students' opinions on science topics/courses taught using scientific narratives and educational games.

Aycan et al. (2002) reported that teaching “Periodic System” topic to fifth and sixth grade students via an educational game entitled “Bingo”; Çavuş and Balçın (2017) concluded that educational game activities used when teaching “Structure and Properties of Matter” topic to seventh grade students and Gençer and Karamustafaoğlu (2020) found that teaching “Still Electricity” topic within the “Electricity in Our Lives” unit to seventh grade students, Yıldız and Şimşek (2021) Teaching the subject of “Matter and Change” with educational games for fifth grade students enabled students to learn units/topics while having fun, to actively participate in science class; ensured that the units/topics were retained in their minds for a longer time. The results of their research indicated that these games facilitated learning the units/topics, increased the interest in science classes, made science courses more educational and fun, and increased students' desire to learn.

## **SUGGESTIONS**

Based on the results of the study, the following recommendations can be put forward:

1. Scientific narratives and educational games may be used to teach science to students at different grades of secondary school.
2. Further research may address determining the opinions of science teachers on whether instructing science topics through educational games corroborated with scientific narratives is effective in students' learning.
3. Science units/topics in the text books that students have difficulty in learning and understanding may be bolstered with educational games and scientific narratives.

4. Educational games supported by scientific stories can be included in textbooks
5. Considering that children spend a lot of time with technological devices in our increasingly digital world, educational games with more digital content can be designed and used in science education to investigate their effects.

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Idea or Notion	Seyda OZDEMIR-Emine Hatun DIKEN
Literature Review	Seyda OZDEMIR-Emine Hatun DIKEN
Yöntem	Seyda OZDEMIR-Emine Hatun DIKEN
Data Collecting	Seyda OZDEMIR
Data Analysis	Seyda OZDEMIR-Emine Hatun DIKEN
Findings	Seyda OZDEMIR-Emine Hatun DIKEN
Discussion and Commentary	Seyda OZDEMIR-Emine Hatun DIKEN

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