International Journal of Computers in Education
2024, Volume 7, Issue 2, 157-180
Research Article

The Effect of Gamification Activities on Students' Achievement in the Sound and Its Properties Unit and Their Attitudes Towards the Science Course

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Abstract – This study aimed to investigate the effects of a gamified learning environment, developed using the Web 2.0 tool Wordwall, on sixth-grade students' academic achievement in the *Sound and Properties* unit and their attitudes toward the Science course. Conducted with an experimental and a control group, the study employed a quasi-experimental design with pre-test and post-test measurements. The experimental group engaged in gamified activities designed to incorporate elements such as competition, leaderboards, certificates, scoring, progression, and visual engagement. In contrast, the control group participated in traditional worksheet-based activities. Data were collected using the *Sound and Properties Unit Achievement Test* (SPUAT) and the *Attitude Scale Toward Science Course* (ASTSC). Statistical analyses, including the Mann-Whitney U Test, Independent Samples T-test, and Wilcoxon Signed-Rank Test, were employed to analyze the data. The findings revealed a significant improvement in the experimental group's academic achievement compared to the control group, highlighting the effectiveness of gamification in enhancing learning outcomes. However, while the experimental group demonstrated a higher mean score in attitudes toward the Science course, the difference between the experimental and control groups was not statistically significant.

These results suggest that gamification positively influences academic achievement in the ***Sound and Properties*** Unit but has a limited impact on students' attitudes toward the Science course within the five-week intervention period. The study contributes to the growing body of research on gamified learning and provides recommendations for future studies, including exploring the impact of specific gamification mechanics, extending the intervention duration, and examining additional variables such as motivation and retention.

Keywords: Academic achievement, attitude towards science course, gamification, science education.

Introduction

Games have served as a source of entertainment throughout history, finding applications across various fields. The act of play is a fundamental aspect of human life, beginning in childhood and persisting into adulthood. Jarvinen (2008) defines games as structured systems with specific settings and rules that engage players, while Prensky (2007) describes them as systems comprising feedback, competition, rules, outcomes, interaction, leaderboards, and similar elements. Beyond traditional games, children increasingly engage with digital games played on computers, phones, and gaming consoles. In recent years, the rapid rise in the popularity of digital games, rivaling even the Hollywood industry, has encouraged educators to explore their potential in educational contexts (Özkan & Samur, 2017). According to Aygül (2019), digital games, owing to their widespread appeal, offer an effective means of achieving curriculum objectives.

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This article is derived from a section of the master's thesis titled 'The Effect of Gamification Supported by Web 2.0 Tools on Students' Academic Achievement and Attitudes Towards the Science Course,' completed within the Science Education master's program of the Department of Mathematics and Science Education at Dumlupınar University Graduate School of Educational Sciences, under the co-supervision of the second author and the supervision of the third author.

https://doi.org/10.5281/zenodo.14583082
Received 29 Oct 2024; Accepted 13 Dec 2024
ISSN: 2636-8722.

Educational games provide students with opportunities to express their emotions, desires, and needs effectively (Yenice, Tunç, & Yavaşoğlu, 2019). These games form the foundation of game-based learning, a student-centered, open-ended, and flexible process characterized by exploration, observation, research, idea generation, and hypothesis testing (Tuğrul, 2014). In game-based learning, students are active participants, while teachers assume a guiding role to support the achievement of learning outcomes (Weisberg, Hirsh-Pasek, & Golinkoff, 2013). Within the constructivist learning approach, teachers facilitate activities and games that empower students to independently discover knowledge. This approach allows learners to apply theoretical concepts practically, understand their surroundings, and adapt to their environment while maintaining active engagement (Çelik, 2017). Numerous studies have highlighted the positive impacts of game-based learning on academic performance, attitude, and motivation (Akın & Atıcı, 2015; Baş & Karamustafaoğlu, 2020; Çil & Sefer, 2021; Okur & Akkuş, 2021; Şentürk, 2020; Tekkuş, 2022; Yazıcıoğlu & Güngören, 2019). A general review of these studies reveals that game-based learning significantly enhances academic achievement, with most studies also reporting favorable effects on students' attitudes, albeit with some exceptions.

The concept of "gamification" emerges as a relevant framework for leveraging digital games in education. While games and gamification share similarities, they are distinct concepts. Gamification refers to the application of game elements in non-game contexts to enhance engagement, interest, and attitudes (Dominguez, Navarrete, & Pages, 2013). It involves adapting non-game scenarios using game mechanics and dynamics. Gamification is prevalent in daily life; for example, the Nike+ app employs gamification to encourage exercise habits (Özkan & Samur, 2017), while step counters award virtual badges for achieving step goals. Similarly, the Duolingo app applies gamification to facilitate foreign language learning. The purpose of gamification is to make the learning process more attractive for learners and to ensure that they gain different learning experiences through a learning environment that is numerous fun activities (Güler &Güler, 2015).

Although games, game-based learning, and gamification share overlapping features, their operational mechanisms differ. Gamification incorporates elements such as leaderboards, badges, competition, and rewards, aligning these features with educational objectives to create competitive and engaging activities for learners. According to Şenocak and Bozkurt (2020), while the primary purpose of games is entertainment, gamification aims to enhance motivation, foster commitment to a system, drive behavioral change for system sustainability, and improve performance—all while maintaining an element of fun.

The use of digital games and gamification enables the creation of virtual learning environments that mirror real-world challenges, facilitating meaningful learning experiences (Vogt, Remold, & Parker, 2016). Gamification supports the comprehension and application of scientific concepts through activities such as science fiction stories, card games, computer games, mobile apps, and virtual reality tools. These methods increase student engagement and make abstract concepts more accessible. Studies have documented the positive effects of gamification on academic achievement, attitude, and motivation (Alcivar & Abad, 2016; Alsawaier, 2018; Bell, 2014; Kılıçel & Ertaş Kılıç, 2021; Bayrak, 2023; Çalgıcı, Yıldırım, & Duru, 2020; Erdoğdu & Karataş, 2016; Harrold, 2014; Şahin, 2015; Tunç, Çakmak, & Güzel, 2018; Ulus, 2021; Weber et al., 2017).

Integrating games and gamification into science education has been shown to positively influence students' learning, attitudes, and motivation (Samur & Cömert, 2019). In science classes, worksheets are commonly used for practice; however, with advancements in technology, adapting activities to digital formats has become essential. Tools such as Kahoot, Educaplay, Edmodo, Wordwall, Quizizz, and Fenaktivite offer opportunities to gamify lesson content. Among these, Wordwall stands out as a Web 2.0 tool that provides customizable, interactive, and printable activity options. It enables the creation of diverse game formats, ranging from simple games for younger students to cognitive-focused activities for advanced learners. Wordwall also supports asynchronous learning, allowing students to engage at their own pace. Its versatility in visual design and functionality makes it a valuable tool for gamifying educational content.

This study aims to investigate the effects of gamified activities on students' achievement in the "Sound and Its Properties" unit of the 6th-grade science curriculum and their attitudes toward science courses. The research addresses the following questions:

1. Is there a significant difference between students' achievement scores in the "Sound and Its Properties" unit from pre-test to post-test?
2. Is there a significant difference in the post-test scores of experimental and control group students for the "Sound and Its Properties" unit?
3. Is there a significant difference between the pre-test and post-test scores of the Attitude Scale Toward Science Course for experimental and control group students?
4. Is there a significant difference in students' attitude scores toward science courses from pre-test to post-test?

Method

Research Design

This study employed a quasi-experimental design to evaluate the effects of gamification activities on students' academic achievement in the *"Sound and Its Properties"* unit and their attitudes toward the science course within the 6th-grade curriculum. In this context, the use of gamification activities was treated as the independent variable, while the dependent variables were students' achievement in the *"Sound and Its Properties"* unit and their attitudes toward the science course.

Participants

The experimental group participated in gamification-based activities, whereas the control group engaged with traditional worksheet-based activities. Measurements for the dependent variables were collected for both the experimental and control groups, with pre-tests and post-tests administered before and after the intervention, respectively. During the intervention period, the experimental procedures were applied exclusively to the experimental group, while the control group followed the standard curriculum without gamification activities (Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz, & Demirel, 2018).

The study involved 30 voluntary 6th-grade students from a secondary school, divided equally into the experimental (15 students) and control (15 students) groups. The research design is outlined in Table 1.

Table 1. Pre-test and Post-test Experimental Model with Control Group

Study Group	Pre-test	Experimental Procedures	Post-test
Experimental Group	Sound and Properties Unit Achievement Test (SPUAT) Attitude Scale Toward Science Course (ASTSC)	Supported by Gamification Activities of the Current Curriculum	(SPUAT) (ASTSC)
Control Group	(SPUAT) (ASTSC)	Supported by Worksheet Activities of the Current Curriculum	(SPUAT) (ASTSC)

Students were randomly assigned to the experimental and control groups after their initial science course averages were calculated. The first group had an average score of 56.04, and the second group

had an average score of 56.03. To maintain impartiality, the assignment was conducted without informing the students (Büyüköztürk et al., 2018). Consequently, the first group was designated as the experimental group, and the second group as the control group. The experimental group consisted of 9 male and 6 female students, while the control group included 10 male and 5 female students, ensuring balanced gender distribution. Gender details are summarized in Table 2.

Table 2. Gender Information of Students

Gender	Experimental Group	Control Group
Female	6	5
Male	9	10
Total	15	15

The pre-test scores for the *"Sound and Its Properties"* unit achievement test for both groups are presented in Table 3.

Table 3. Pre-test Scores of the "Sound and Its Properties" Unit Achievement Test for Experimental and Control Groups

Group	Pre-test Score	N	Sd
Experimental Group	5.47	15	0.36
Control Group	5.67	15	0.44

The average pre-test score of the experimental group was 5.47, while that of the control group was 5.67.

Data Collection Tools

Sound and Properties Unit Achievement Test (SPUAT)

The *"Sound and Properties Unit Achievement Test (SPUAT)"* developed by Aksoy and Özcan (2020) was utilized to measure students' academic performance regarding the *"Sound and Its Properties"* unit. The test comprises 17 multiple-choice questions, with a maximum possible score of 17 and a minimum of 0. Students were given 40 minutes to complete the test. The average item difficulty index of the test was reported as 0.471, categorizing it as moderately difficult. The discrimination index was 0.562, indicating that the test effectively differentiates between high- and low-achieving students. The KR-20 reliability coefficient of the test was determined to be 0.785, placing it within the acceptable range for reliability (0.60–0.90). The researchers also validated the test by aligning the questions with the learning outcomes of the *"Sound and Properties"* unit, supported by a criterion table.

Attitude Scale Toward Science Course (ASTSC)

To evaluate students' attitudes toward the science course, the *"Attitude Scale Toward Science Course (ASTSC)"* developed by Taşkın and Aksoy (2019) was employed. The scale consists of 12 items measured on a five-point Likert scale. The internal consistency coefficient of the scale was calculated as 0.862, indicating high reliability.

Data Collection Procedures

Table 4 presents the weekly planning of in-class activities conducted with the experimental and control groups.

Table 4. Weekly Planning of In-Class Activities Conducted with the Groups

Week	Experimental Group (Gamification)	Control Group (Worksheet)
1st Week	The topic of Sound Propagation is covered according to the lesson plan using the textbook (4 hours). Activities related to Sound Propagation are conducted using the Wordwall application (2 hours).	The topic of Sound Propagation is covered according to the lesson plan using the textbook (4 hours). Worksheets related to Sound Propagation are solved and answered (2 hours).
2nd Week	The topic of Sound Perception in Different Environments is covered according to the lesson plan using the textbook (4 hours). Activities related to Sound Perception in Different Environments are conducted using the Wordwall application (2 hours).	The topic of Sound Perception in Different Environments is covered according to the lesson plan using the textbook (4 hours). Worksheets related to Sound Perception in Different Environments are solved and answered (2 hours).
3rd Week	The topic of Sound Speed is covered according to the lesson plan using the textbook (4 hours). Activities related to Sound Speed are conducted using the Wordwall application (2 hours).	The topic of Sound Speed is covered according to the lesson plan using the textbook (4 hours). Worksheets related to Sound Speed are solved and answered (2 hours).
4th Week	The topic of Sound Interaction with Matter is covered according to the lesson plan using the textbook (4 hours). Activities related to Sound Interaction with Matter are conducted using the Wordwall application (2 hours).	The topic of Sound Interaction with Matter is covered according to the lesson plan using the textbook (4 hours). Worksheets related to Sound Interaction with Matter are solved and answered (2 hours).
5th Week	The topic of Sound Interaction with Matter is covered according to the lesson plan using the textbook (4 hours). Additionally, overall Wordwall activities related to the entire unit are conducted (2 hours).	The topic of Sound Interaction with Matter is covered according to the lesson plan using the textbook (4 hours). Worksheets related to Sound Interaction with Matter are solved and answered. Additionally, worksheets related to the entire unit are solved (2 hours).

Data Collection Process

Following the administration of the pre-tests, lessons with both the experimental and control groups commenced. For the experimental group, gamification activities were integrated into the curriculum using the Wordwall Web 2.0 tool. These gamified activities were meticulously designed by the teacher and reviewed by two subject matter experts to ensure alignment with learning outcomes and appropriateness for the students' skill levels. Both groups participated in four hours of shared instruction each week, with an additional two hours allocated specifically for science-related activities. The weekly activities implemented with the experimental group are detailed below:

Week 1: Gamification Activities on Sound Propagation

During the first week, gamification activities focused on the topic of Sound Propagation and the mediums through which sound travels were conducted using Wordwall. A total of five interactive activities were designed for this week. These activities included:

- "Whack-a-Mole"
- "Sliding True or False"
- "Forest-Themed Matching"
- "Fill in the Blanks"

Students actively participated in these games using their personal tablets and smartphones brought to school. The Wordwall application adhered to gamification principles, providing immediate feedback on both correct and incorrect answers. To enhance engagement, extra points were awarded to students who demonstrated speed and accuracy in completing the tasks. At the conclusion of each game, leaderboards were displayed to highlight individual performance. Certificates of achievement were awarded to the top three students at the end of the week.

Through these activities, students engaged with key elements of gamification, including badges, leaderboards, competition, speed, levels, points, and feedback. These features not only enhanced their motivation and engagement but also fostered a competitive and enjoyable learning environment.

Figure 1. Sample Game: "Whack-a-Mole"

Sıra	Adı	Skor
1	Melike	1383
2	Aycan	1159
3	Emre	736
4	Sevde şen	580
5	Melih ozay	506
6	Berat vural	497
7	Samet	410
8	Ayşenur	368
9	Recep	362
10	berkay	195

Figure 2. Sample Leaderboard: "Week 1 Whack-a-Mole Game Leaderboard"

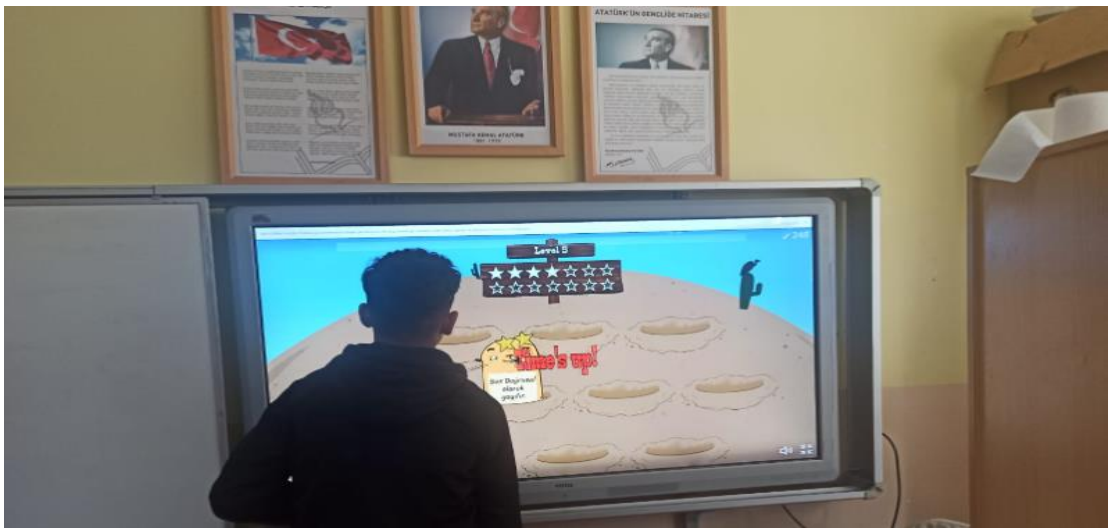

Figure 3. Student Playing Whack-a-Mole Game with the Help of a Smart Board

Figure 4. Achievement Certificate for the Week One Winner

Week 2: Gamification Activities on "Sound Perception in Different Environments"

In the second week, five gamification-based activities were implemented, focusing on the topic of "Sound Perception in Different Environments." These activities included:

- “Quiz Show Competition”
- “Box Opening”
- “Group Ranking”
- “Spin the Wheel”
- “Sliding True or False Questions Test”

Each activity was carefully designed to incorporate key gamification elements, such as leaderboards, competition, levels, hints, timed challenges, and immediate feedback. Notably, the Spin the Wheel

game involved a competitive component where students answered questions independently, promoting the development of higher-order cognitive skills and deeper engagement with the content.

Students actively participated in these activities using tablets and smartphones they brought from home. For students without personal devices, school resources were made available; some utilized computers within the school, while others accessed smart boards in vacant classrooms.

These measures ensured equitable access and participation. All students in the experimentgroup engaged fully with the activities, fostering an interactive and dynamic learning experience.

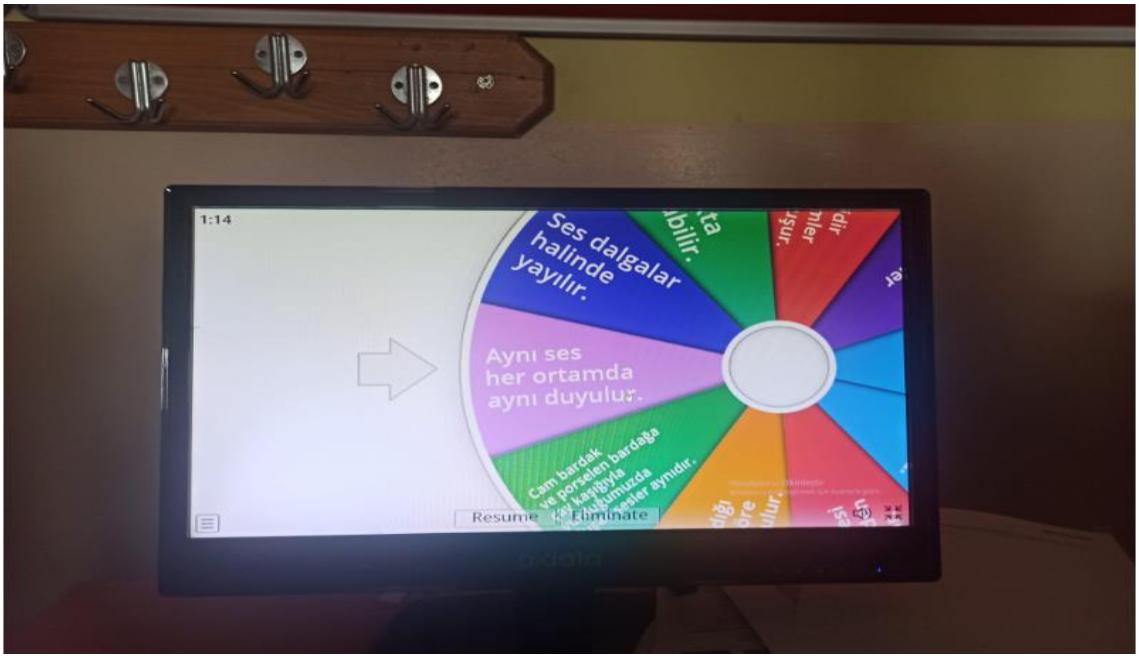

Figure 5. Example Game: "Week 2 Spin the Wheel"

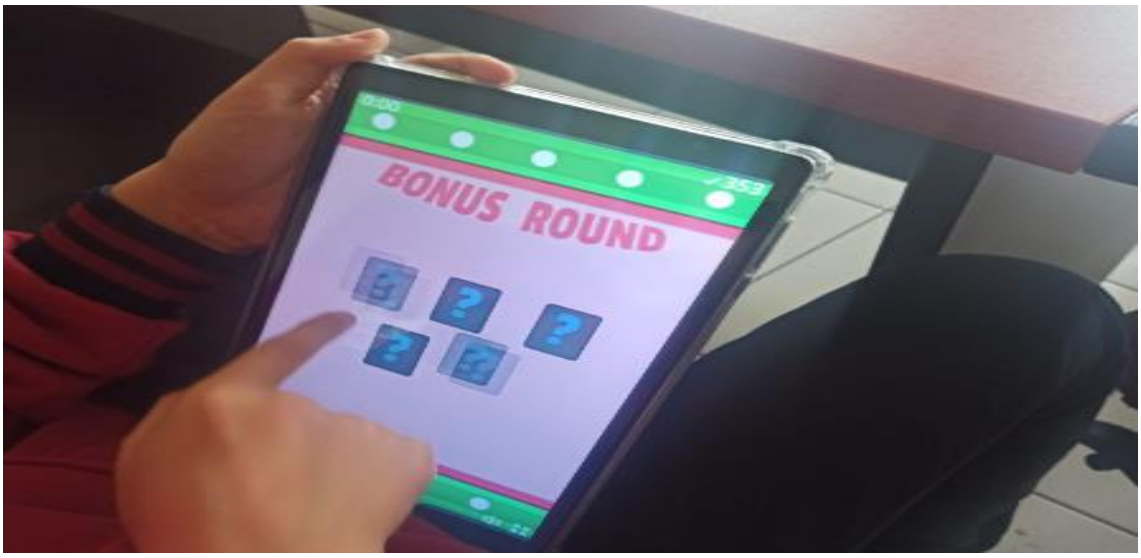

Figure 6. Example Game: "Week 2 Quiz Show"

Sıra	Adı	Skor
1	Melike	19
2	berkay	14
3	Emre	12
4	.	11
5	Samet	11
6	Sevde şen	11
7	süüüü CR7 ekin	10
8	Melih ozay	9
9	Recep	8
10	Adem köse	7

Figure 7. Example Leadership Table: "Week 2"

Week 3: Gamification Activities on "Sound Speed"

In the third week, four gamification-based activities were conducted focusing on the topic of "Sound Speed." These activities included:

- “Quiztest”
- “Airplane”
- “Group Ranking”
- “Test”

Each activity was designed to incorporate essential gamification elements, such as leaderboards, level progression, timed challenges, and competitive play. These features were aimed at fostering engagement and motivation while encouraging students to actively participate in the learning process.

Students approached these activities in an interactive and enjoyable manner, creating a dynamic and stimulating learning environment. To further enhance motivation, certificates of achievement were awarded to the top three students based on their overall performance across all activities.

Figure 8. Sample Game: "Week 3 Airplane Game"

The "Airplane" game is a well-designed Wordwall gamified activity that incorporates various gamification elements and features a narrative. It was one of the games that students enjoyed the most, as they engaged in it with a sense of fun and competition.

Figure 9. Students Playing the Airplane Game

Sıra	Adı	Skor	Zaman
1	Çok kolaydI	4	27.4
2	Ozlem	4	29.4
3	DYK Birkan	4	35.7
4	Merve	4	35.9
5	ela kara	4	36.4
6	Ömer	4	36.5
7	DYK FATMA	4	37.0
8	Umut	4	37.8
9	ctuyıo	4	38.5
10	Azra beyda	4	39.6

Figure 10. Example Leaderboard for the "Week 3 Airplane Game"

Week 4: Gamification Activities on "Sound Interaction with Matter"

In the fourth week, four gamification-based activities were designed and implemented, focusing on the topic of "Sound Interaction with Matter." These activities included:

- “Box Opening”
- “Quiz Show”
- “Balloon Popping”
- “Maze Chase”

The Balloon Popping game provided an engaging and competitive experience, where students popped balloons to release boxes containing the correct answers. This activity combined excitement with a sense of urgency, as students advanced through levels and competed against the clock. Similarly, the Maze Chase game, inspired by the classic Pacman, required students to navigate through a maze while avoiding obstacles to reach the correct answers. This game emphasized problem-solving and quick decision-making skills.

These activities were meticulously designed to incorporate essential gamification components such as competition, level progression, time-based challenges, and interactive engagement. By fostering a dynamic and competitive environment, these games effectively enhanced students’ participation and motivation.

Figure 11. Sample Game: "Balloon Popping, Week 4"

Figure 12. Sample Game: "Maze Chase, Week 4"

Sıra	Adı	Skor	Zaman
1	Aycan	9	4:05
2	Fhfgmffgg	9	4:49
3	6b candır gerisi yal	7	4:06
4	melik	7	4:18
5	Chainsaw mam	5	2:51
6	Berkay	4	2:31
7	Emre	4	2:43
8	Farşit	4	2:53
9	Ayşenu	4	3:18
10	zeynep	3	2:28

Figure 13. Sample Leaderboard: "Maze Chase, Week 4"

Week 5: Gamification Activities on "Interaction of Sound with Matter"

In the fifth week, four gamification-based activities focusing on "Interaction of Sound with Matter" were conducted using the Wordwall platform. These activities included:

- "Airplane"
- "Balloon Burst"

- "Quiz Show"
- "Maze Chase"

In the final stage of the activities, students' performances were highlighted on leaderboards, fostering a sense of accomplishment and competitive spirit. To further motivate and reward participation, badges and achievement certificates were presented to the top three students based on their performance in the competitions.

These activities not only enhanced engagement but also provided a dynamic and interactive environment that encouraged active participation and reinforced learning objectives.

Figure 14. Example Achievement Certificate: "First Place Achievement Certificate for Sound and Its Properties"

Studies Conducted with the Control Group

During the five-week study period, the lessons conducted with the experimental group were delivered to the control group using worksheets obtained from the Education Information Network (EBA) and other educational platforms. The content of the worksheets was carefully evaluated for alignment with the gamification activities implemented in the experimental group, as well as for their appropriateness in meeting the learning outcomes and addressing the students' academic levels.

This review process was carried out by two experts in Science Education and one expert in Assessment and Evaluation. Following their feedback, necessary adjustments and revisions were made to ensure the worksheets' quality and relevance before they were implemented in the control group.


ÇALIŞMA YAPRAĞI

Kazanım: F.6.5.1.1. Sesin yayılabildiği ortamları tahmin eder ve tahminlerini test eder.

1. Aşağıda verilen ortamlardaki sesin yayılma-yayılmama durumunu belirtini:

	Yayılır.	Yayılmaz.
I. ▶ Tren rayında		
II. ▶ Uzayda		
III. ▶ Su altında		
IV. ▶ Atmosferde		
V. ▶ Havası alınmış cam fanusda içinde		

Figure 15. A Sample Section from the Week 1 Worksheet Administered to the Control Group

Post-Test Implementation Phase

Following the five-week intervention period, the *Sound and Properties Unit Achievement Test* and the *Attitude Scale Toward Science Course* were administered to both the experimental and control groups on separate days. The administration process proceeded smoothly, with no issues reported before, during, or after the implementation.

All students who participated in the pre-tests also completed the post-tests, ensuring consistency in data collection. Additionally, students answered the questions within the allocated time, and no challenges related to time management were observed

Data Analysis

Quantitative data for this study were collected using the *"Sound and Properties Unit Achievement Test"* and the *"Attitude Scale Toward Science Course."* The normality of the data distribution within the study group was evaluated to ensure the appropriateness of subsequent statistical analyses. For sample sizes of 30 or fewer, the Shapiro-Wilk normality test is recommended (Büyüköztürk, 2013). Accordingly, the Shapiro-Wilk test was utilized in this study to determine whether the data followed a normal distribution. The results of the normality analysis conducted using the Shapiro-Wilk test are presented in Table 5.

Table 5. Results of the Normality Test

Variables	Variables	Shapiro-Wilk		
		Value	Sd	p
SPUAT Pre-Test	Experimental	.85	15	,017
	Control	.75	15	,001
ASTSC Pre-Test	Experimental	.93	15	,30
	Control	.93	15	,29
SPUAT Post-Test	Experimental	.95	15	,49
	Control	.95	15	,57
ASTSC Post-Test	Experimental	.92	15	,19
	Control	.,96	15	,76

According to the Shapiro-Wilk normality test, a significance value of less than 0.05 indicates that the data do not follow a normal distribution, whereas a value greater than 0.05 suggests that the data are normally distributed (Büyüköztürk, 2013). Based on these criteria, it was observed that the pre-test scores for the *Sound and Properties Unit Achievement Test (SPUAT)* in both the experimental and control groups exhibit a non-normal distribution ($p < 0.05$). In contrast, the post-test scores for the SPUAT demonstrate a normal distribution ($p > 0.05$).

Furthermore, an examination of Table 3 reveals that the pre-test and post-test scores for the *Attitude Scale Toward Science Course (ASTSC)* follow a normal distribution ($p > 0.05$).

In addition to the Shapiro-Wilk test, skewness and kurtosis values were also analyzed to further assess the distribution of the data. Values within the range of -1.5 to +1.5 are considered indicative of a normal distribution, while values outside this range suggest a non-normal distribution (Büyüköztürk, 2013). Table 6 provides the skewness and kurtosis values for all pre-tests and post-tests conducted with the study groups.

Table 6. Skewness and Kurtosis Values

Variables	Groups	Skewness	Kurtosis
		Z	Z
SPUAT Pre-Test	Experimental	,27	-1,36
	Control	2,26	6,78
ASTSC Pre-Test	Experimental	-,11	-1,38
	Control	-,28	-,50
SPUAT Post-Test	Experimental	,14	-1,24
	Control	,59	-,62
ASTSC Post-Test	Experimental	-,64	-,03
	Control	-,74	-,87

An examination of Table 6 indicates that, consistent with the results of the Shapiro-Wilk normality tests, the skewness and kurtosis values for the groups—except for the SPUAT pre-test—also fall within the acceptable range for normal distribution. Additionally, histogram graphs were analyzed to verify these findings.

Based on these assessments, the following statistical methods were applied:

- The Mann-Whitney U test was utilized to compare the pre-test results of the *Sound and Properties Unit Achievement Test (SPUAT)* between the groups, as the pre-test data did not follow a normal distribution.
- The independent samples t-test was employed for the comparison of post-test results, which were found to exhibit a normal distribution.
- To compare pre-test and post-test results within the experimental and control groups, the Wilcoxon Signed-Rank Test was used.

These statistical methods were chosen to ensure appropriate analyses based on the distribution characteristics of the data.

Limitation

The scope of this study is defined by the following limitations:

1. The study group comprises 30 students enrolled in 6th grade at a public elementary school in Kütahya, Turkey, during the 2022-2023 academic year.
2. The findings are limited to the data obtained through the measurement tools and techniques utilized in the study.

3. The content of the activities is restricted to the sub-learning objectives within the "Sound and Properties" unit of the Science curriculum.
4. The study is confined to the materials developed specifically for the research.
5. The study is limited to the activities designed for the research.
6. The study is conducted within the scope of a single academic term.

Findings

Findings Related to the First Subproblem of the Study

The first subproblem of the study was defined as: *"Is there a significant difference in students' 'Sound and Properties' unit achievement scores between the pre-test and post-test?"*

An analysis of the test scores reveals that the average post-test score for the control group **(**$\bar{X}$ **=** 7.53) is higher than its pre-test score ($\bar{X}$ = 5.67). Similarly, the experimental group's average post-test score ($\bar{X}$ = 10.60) surpasses its pre-test score ($\bar{X}$ = 5.47).
The results of the normality tests, as presented in Table 5, indicate that the pre-test scores for the control group do not follow a normal distribution ($p = 0.017 < 0.05$), whereas the post-test scores demonstrate a normal distribution ($p = 0.57 > 0.05$). Similarly, the pre-test results for the experimental group deviate from normality ($p = 0.001 < 0.05$), while the post-test results conform to a normal distribution ($p = 0.49 > 0.05$).
Given these findings, the non-parametric Wilcoxon Signed-Rank Test was applied to statistically evaluate the differences between the pre-test and post-test scores for both groups, as it is suitable for non-normally distributed data (Büyüköztürk, 2013). The results of the Wilcoxon Signed-Rank Test are detailed in Table 7.

Table 7. Wilcoxon Signed-Ranks Test Results for Pre-Test and Post-Test Scores of the Control Group and Experimental Group for the Sound and Properties Unit

Group	Post-Test - Pre-Test	N	Rank Average	Rank Total	z	p
Control	Negative Ranks	4	2,63	10,50	-2,01	0,04
	Positive Ranks	7	7,93	55,50		
	No Difference	4				
Experiment	Negative Ranks	1	1,50	1,50	-3,40	0,00
	Positive Ranks	14	8,46	118,50		
	No Difference	0				

According to Table 7, the Wilcoxon Signed-Ranks Test was conducted to examine whether there were significant differences between the pre-test and post-test scores of the experimental and control groups for the *Sound and Properties Unit*. The analysis revealed statistically significant differences in both the experimental group ($z = -3.40$, $p = 0.001 < 0.05$) and the control group ($z = -2.01$, $p = 0.045 < 0.05$).

The positive rank of the score differences (post-test scores) indicates that the instructional methods employed—gamification for the experimental group and worksheets for the control group—had a significant impact on the achievement scores as measured by the *SPUAT*.

Findings Related to the Second Sub-Problem

The second subproblem of the study is defined as: *"Is there a significant difference between the post-test scores of the experimental and control groups for the Sound and Properties Unit?"*

An analysis of the test scores reveals that the average post-test score on the *Sound and Properties Unit Achievement Test* for the experimental group is $\bar{X}$ = 10.60, compared to a pre-test average of $\bar{X}$ = 5.47. In contrast, the control group's average post-test score is $\bar{X}$ = 7.53, with a pre-test average of $\bar{X}$ = 5.67. Based on these averages, it can be observed that the experimental group's post-test scores are higher than those of the control group.
The Mann-Whitney U test indicated that the difference between the pre-test scores of the experimental and control groups was not statistically significant (U = 111.00, p = 0.95 > 0.05).
An examination of Tables 5 shows that the post-test scores for both the experimental group (p = 0.49 > 0.05) and the control group (p = 0.57 > 0.05) follow a normal distribution. To evaluate the significance of the difference between the post-test scores of the experimental and control groups, an Independent Samples T-test was conducted. The results of this test are presented in Table 8.

Table 8. Results of the Independent Samples T-Test for the Post-Test Scores of the Experimental and Control Groups for the Sound and Properties Unit

Group	N	Mean	Standard Deviation.	sd	t	p
Experimental	15	10,60	4,04	28	2,22	0,034
Control	15	7,53	3,48			

Upon examining Table 8, it is evident that the difference in scores between the experimental group, which participated in gamified activities, and the control group, which engaged in worksheet activities, is significant in favor of the experimental group (t = 2.22, p = 0.03 < 0.05). This suggests that the gamified activities utilized after the lesson instruction have a positive impact on academic achievement.

Findings Related to the Third Subproblem

The third subproblem of the study is stated as: *"Is there a significant difference between the pre-test and post-test scores of the students in the experimental and control groups on the Attitude Scale Toward Science Course?"*

An analysis of the test scores indicates that the average pre-test score for the control group (M = 38.40) shows a slight difference compared to the average post-test score (M = 36.87), with the pre-test score being marginally higher. This suggests a minor decline in the control group's attitude scores in the final assessment.
In contrast, the experimental group demonstrates an increase in attitude scores, with an average post-test score of $\bar{X}$ = 40.53, compared to an average pre-test score of $\bar{X}$ = 37.20.
As shown in Tables 5, the pre-test (p = 0.30 > 0.05) and post-test (p = 0.19 > 0.05) scores of the control group follow a normal distribution. Similarly, the pre-test (p = 0.30 > 0.05) and post-test (p = 0.19 > 0.05) scores of the experimental group also exhibit a normal distribution.
To compare the pre-test and post-test scores within the groups, a dependent samples t-test was employed (Büyüköztürk, 2013). The results of this test are presented in Table 9.

Table 9. Dependent Samples T-Test Results for the Control Group's Attitude Scale Toward Science Course Pre-test and Post-test Scores

Group		N	Mean	Standard Deviation.	sd	t	p
Control	ASTSC Pre-test	15	38,40	8,50	14	0,97	0,35
	ASTSC Post-test	15	36,87	10,00			
Experimental	ASTSC Pre-test	15	37,20	6,83	14	-2,20	0,046
	ASTSC Post-test	15	40,53	7,77			

An examination of Table 9 reveals the results of the Dependent Samples T-test conducted to compare the pre-test and post-test scores of the *Attitude Scale Toward Science (ASTSC)* for the control group. The analysis indicates that the difference between the pre-test and post-test scores is not statistically significant ($t = 0.97$, $p = 0.35 > 0.05$).

In contrast, Table 9 also presents the results of the Dependent Samples T-Test analyzing the difference between the pre-test and post-test scores on the *Attitude Scale Toward Science Course (ASTSC)* for the experimental group, which participated in gamified activities following the common topic presentation. The findings demonstrate a statistically significant difference between the pre-test and post-test scores ($t = -2.20$, $p = 0.046 < 0.05$).

These results suggest that the use of gamification activities had a positive effect on the experimental group's attitudes toward the science course.

Findings Related to the Fourth Subproblem of the Research

The final subproblem of the research was defined as: *"Is there a significant difference between the post-test scores of the Experimental and Control groups regarding their attitudes toward the Science course?"*

An analysis of the post-test scores reveals that the average *Attitude Scale Toward Science Course (ASTSC)* score for the Experimental group is $\bar{X} = 40.53$, whereas the average score for the Control group is $\bar{X} = 36.87$. These results indicate that the Experimental group achieved higher average post-test scores compared to the Control group.

Tablo 10. Results of the Independent Groups T-Test for FBTÖ Post-test Scores of the Experimental and Control Groups

Group	N	Mean	Standard Deviation	sd	t	p
Experimental	15	40,53	7,77	28	1,12	0,27
Control	15	36,87	10,02			

An examination of Table 10 reveals that the difference between the Experimental group, which participated in gamification activities, and the Control group, which engaged in worksheet-based activities, was not statistically significant ($p = 0.27 > 0.05$). This finding suggests that the use of gamification activities and traditional worksheets in the instruction of the *Sound and Properties* unit did not result in a significant difference in students' attitudes toward the Science course.

Discussion and Conclusion

Results Related to the Academic achievement test of the Sound and Characteristics Unit

This study investigated the effects of a gamified learning environment, developed using Web 2.0 tools, on the academic performance of sixth-grade students in the *Sound and Characteristics* unit and their attitudes toward the Science course. The findings from the study are discussed below, along with the results.

A significant difference was observed between the pre-test and post-test scores of both the experimental and control groups on the *Academic Achievement Test* for the *Sound and Characteristics* unit. Further analysis of the post-test scores revealed that students in the experimental group, who participated in gamified activities, achieved higher scores than those in the control group. This difference was statistically significant in favor of the experimental group.

The study findings suggest that the games created using the Wordwall tool—incorporating elements such as competition, certificates, scoring, progression, visual engagement, and other gamification components—contributed to the improved performance of the experimental group. It is believed that features such as leaderboards and achievement certificates motivated students to strive for higher rankings, which positively influenced their academic performance. Additionally, the visually appealing nature of the games may have facilitated better retention of concepts.

This improvement aligns with the constructivist approach emphasized in the Science curriculum, which allows students to learn through hands-on experiences. A review of the literature supports these findings, with studies reporting that gamification positively affects academic performance in various disciplines beyond Science (Ak & Oruç, 2022; Hüner, 2018; Yıldırım, 2016; Weber et al., 2017; Dominguez et al., 2013; Mohammed, 2018; Alcivar & Abad, 2016; Ares et al., 2018; Chang et al., 2015). Furthermore, research specific to Science education similarly indicates that gamification enhances academic achievement (Tunç, Çakmak, & Güzel, 2018; Karayılan, Çakmak, & Güzel, 2018; Bayrak, 2013; Akkaya, 2020; Ulus, 2021). Learners' participation in lessons through gamification is greater and more active than their participation in other lessons, and students tend to find these lessons more exciting and engaging than those without gamification (Zsoldos-Marchis, 2020). However, not all findings in the literature align with the results of this study. Some studies focusing on subjects other than Science report no significant impact of gamification on academic performance (Bolat et al., 2017; Meşe, 2016; Tunga & İnceoğlu, 2020; Turan, Avinç, Kara, & Göktaş, 2016; Türkmen, 2017; Türkmen & Soybaş, 2019; Hanus & Fox, 2015).

The issue of critical teaching-learning science subjects, such as mathematics and natural sciences, often tend to be characterized by students as tricky, difficult to understand or too bored (Setiawa & Soeharto, 2020). teacher is essential, as he/she is the one who plans the educational practice, evaluates the type of each student, chooses the materials, the pedagogical strategies and how students will receive feedback (Zourmpakis, Papadakis & Kalogiannakis, 2022). For this reason, teachers are looking for ways to motivate their students by teaching the lessons in a fun way. To maximize the effectiveness of gamification in education, teachers must exercise careful consideration when selecting gamified content. By doing so, they can ensure that technology is applied in a way that optimally supports learning. A key objective for educators leveraging gamification tools is to capture and sustain students' interest. Achieving this requires meticulous attention to the design and functionality of gamified applications, starting with their underlying mechanisms. These mechanisms are pivotal as they encompass the rules, algorithms, and player interactions that define the game experience. Ultimately, the goals and structure of a gamified experience are shaped by the learning outcomes defined by the teacher during the development phase (Putra & Yasin, 2021).

Results Related to Attitude Toward Science Course

Regarding students' attitudes toward the Science course, a significant difference was found between the pre-test and post-test scores of the experimental group. However, no significant difference was observed in the control group. While the experimental group's average post-test attitude score was higher than that of the control group, statistical analysis revealed that the difference between the post-test scores of the two groups was not statistically significant.

Based on these results, it cannot be conclusively stated that gamified activities have a positive impact on students' attitudes toward the Science course. A review of the literature reveals mixed findings: some studies report that gamified activities positively affect attitudes toward Science (Samur, 2015; Yıldırım, 2016; Alcivar & Abad, 2018; Chen et al., 2018; Ulus, 2021), while others indicate no significant impact (Şahin, 2015; Akkaya, 2020; Türkmen & Soybaş, 2019; Türkmen, 2017).

Several factors may explain this inconsistency. Changing attitudes is often a long-term process, and many studies implementing gamification report intervention periods of 3 to 6 weeks, which may not be sufficient to effect meaningful changes in attitudes. In this study, the limited five-week duration of the intervention may have contributed to the lack of significant change in students' attitudes toward the Science course.

This study highlights the significant benefits of gamified learning activities in improving students' academic performance and attitudes toward science courses. By leveraging the motivational and interactive aspects of gamification, educators can create enriching learning experiences that foster engagement and achievement. The findings provide a compelling case for the broader adoption of gamification in educational contexts, paving the way for innovative and effective teaching practices.

Implications for Educational Practice

Integration of Gamification into Curriculum Design

The findings highlight gamification as a powerful tool for enhancing academic achievement and student engagement. Particularly in the context of science education, it is recommended to integrate gamified elements into instructional plans to foster more interactive and effective learning experiences.

Utilization of Web 2.0 Tools

Tools like Wordwall provide versatile platforms for designing gamified activities that align with diverse learning objectives and student skill levels. These tools can deliver immediate feedback, encourage healthy competition, and track progress, all contributing to improved learning outcomes.

Suggestions

This study, conducted using the innovative Web 2.0 tool Wordwall, which integrates comprehensive gamification elements, aims to support future research in this field. Additionally, the findings are expected to serve as a valuable resource for researchers exploring gamification tools, particularly in the context of widely utilized online platforms. Based on the results of this study, the following recommendations can be proposed for future research:

- **Investigating Gamification Mechanisms:** It is recommended to identify the specific mechanisms and components within gamified learning environments that have the most significant impact on students' attitudes and achievements. Understanding which elements are most effective could contribute to the more strategic and impactful design of gamification strategies.
- **Employing Mixed Methods:** Instead of relying solely on quantitative data, future research could be enriched by adopting mixed methods. Conducting interviews with students and

collecting qualitative data would allow for a deeper and more comprehensive exploration of the effects of gamification.

- **Extending the Implementation Period:** Considering that changes in attitudes often require prolonged interventions, extending the duration of gamified activities beyond six weeks could yield more detailed insights. A longer implementation period would enable a more thorough analysis of changes in students' attitudes.
- **Incorporating Multiple Experimental Groups:** Future studies could include multiple experimental groups to compare the effects of different gamification strategies or tools. This approach would provide a clearer understanding of which strategies or tools are more effective in enhancing educational outcomes.
- **Exploring Different Grade Levels:** Extending the study to different age groups or grade levels could help investigate whether the impact of gamification varies with age or developmental stage. Such research would provide valuable insights into the effectiveness of gamification across a range of student demographics.
- **Examining Additional Variables:** Beyond examining the effects of gamification on attitudes and achievement, future research could consider variables such as motivation, retention, or engagement. Including these factors would allow for a more holistic understanding of the potential benefits and challenges associated with gamification in education.

By addressing these recommendations, future studies could build upon the findings of this research and contribute to the growing body of knowledge on gamification in education. Such contributions have the potential to further enhance student learning experiences and improve the efficacy of gamified learning environments.

Conflict of Interest Statement

"There is no conflict of interest among the authors of this study."

Funding Statement

"This study has not been supported by any institution or organization."

Acknowledgments

"We would like to thank all the students who contributed to our study."

Ethical Considerations

"This study adhered to all the rules outlined in the 'Regulation on Scientific Research and Publication Ethics' issued by Higher Education Institutions. None of the actions listed under the section 'Actions Against Scientific Research and Publication Ethics' in the second part of the regulation were performed."

Table 11. Ethics Committee Information

Name of the Ethics Committee that Conducted the Evaluation	:	Kütahya Dumlupınar Üniversitesi Lisansüstü Eğitim Enstitüsü Müdürlüğü
Date of the Ethics Evaluation Decision	:	30.03.2023
Ethics Evaluation Document Number	:	190253

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