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Using Gamification in Science Learning: Achievement, Attitudes, and Skills

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Abstract

This study explores how gamification enriched learning activities affect science learning in terms of achievement, attittues and science learning skills. Fourty-three 6^{th} grade students participated in the study which employed a quasi-experimental design that included an experimental group receiving science education through gamification activities over a eight week period. The analysis of the data revealed that after the eight weeks of intervention, the control group students' academic achievement increased, while their attitude towards science and science learning skills remained similar. In contrast, experimental group students' academic achievement, attitude towards science, and science learning skills significantly increased after science instruction that included gamification elements. The split plot Anova results showed that the academic achievement, attitude towards science, and science learning skills of the students in the experimental group were statistically higher than those of the students in the control group. In light of these results, it is recommended that in-service training be provided to teachers to increase the use of gamification elements in science education.

Keywords: Gamification, Academic achievement, Attitude towards science, Science learning skills

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Introduction

The game, as ancient as human history and a fundamental aspect of childhood, is characterized as an entertainment activity governed by specific rules that fosters enjoyable experiences while enhancing intelligence and skills (TLA, 2019). From an educational viewpoint, a game can be understood as an effective learning experience, whether or not it has a defined goal, and can involve rules or be unstructured. It is an activity in which children actively and joyfully engage, promoting their physical, social, and cognitive development (Uskan & Bozkuş, 2019). Considering the interests and needs of the new generation of students, the necessity of incorporating educational technologies into educational environments where traditional methods are used becomes evident (Potts et al., 2010). There is a need for learning-teaching environments designed with innovative classroom techniques and incorporating educational technologies that increase the quality of education and make learning more effective as well as lasting (Hayırsever & Orhan, 2018). Gee (2005) observed that people spend a lot of time on digital games and found it interesting that they spend hours trying to pass a difficult level in the game. In this context, it is suggested that more effective learning environments can be created by combining the complex, long, difficult, and boring learning process with the entertainment aspect of games (Gee, 2005). Emergingas a new concept in the field of education, gamification ensures learners' interest in the learning process, provides them with the confidence that they can have fun while learning (Werbach & Hunter, 2012). Studies on gamification indicate that gamification used in instructional environments is promising (Brom et al., 2011). Gamification is defined as "the use of game-based thinking and game components to engage people and solve problems" (Zichermann & Cunningham, 2011). The game design elements should be applications that provide motivation, engagement, and continuity for individuals (Deterding et al., 2011). Gamification elements are manifested in many different game contents such as goals, story, freedom of choice, rules, freedom to make mistakes, rewards, and levels. The main features of gamification design consist of dynamics, mechanics, and components. These elements include tasks, challenges, achieving a goal, characters, using resources, using power, endless possibilities, points, virtual money, leaderboards, teams, badges, and countdowns (Werbach & Hunter, 2012). Gamification allows students to learn through experiential learning, giving them the opportunity to take risks and make mistakes. Thus, students feel more comfortable in the learning process and open to new experiences (Kapp, 2012). Research demonstrates that students instructed in gamified learning environments in science education learn while having fun, participate in the lesson (Rouse, 2013; Ulus, 2021; Zourmpakis, Kalogainnakis & Papadakis, 2023), and achieve better retention (Ağırgöl et al., 2022; Karayılan Tunç, 2019). The enjoyable and entertaining game environment presented through gamification activities positively affects students' motivation (Lee & Hammer, 2011). Consequently, positively affected motivation encourages students to show more participation and effort in the learning process by instilling a sense of success in the lesson. This situation brings about success and lasting learning (Zhan et al., 2022). Investigating a gamified mobile learning application in science classroom for engagement and achievement, Pechenkina et al. (2017) found that students learning with gamification showed increased participation in the lesson and higher levels of academic success. It can be said that one of the important factors affecting science success is attitudes towards science. It is noted that one of the most important factors affecting attitudes towards science is enjoying the lesson (Ilgaz, 2006). The learning environment becomes interes rising and fun for the student with the integration of gamification elements into education. In this case, the gamification elements used in science lessons motivate students to participate in the lesson. By leveraging the pleasurable, entertaining, and motivating power of games, gamification enables learners to develop a positive attitude towards science (Rincon- Flores & Santos-Guevara, 2021). Zourmpakis et al. (2023) emphasize that students like the gamification elements integrated into science education, are motivated to learn science in gamified environments, and show interest.

The literature review in the field shows that there are studies explore the impact of gamification-enhanced instruction on science achievement (Araya et al., 2019; Fleischmann & Ariel, 2016; Karamert, 2019; Kumar & Khurana, 2012; Pechenkina et al., 2017; Zhan et al., 2022) and attitudes towards science (Abramovich et al., 2013; Kyewski & Kramar, 2018; Marcos et al., 2014; Şahin, 2022; Zourmpakis et al., 2023). However, the literature review in the field did not reveal any research that investigated the influence of gamification enriched instructional activities on science achievement, attitudes towards science and science learning skills at the same time. Thus, this research aims to investigate how gamification-enriched instruction influences these three areas. This study is significant as it contributes to the existing literature, provides insights for similar research, and offers guidance for teachers in their instructional practices. To address these objectives four research questions were formulated:

1. Is the implementation of science education enriched with gamification activities effective in improving students' academic achievement?
2. Is the implementation of science education enriched with gamification activities effective in improving students' attitudes towards science?
3. Is the implementation of science education enriched with gamification activities effective in improving students' science learning skills?

Method

Research Design: This research explored how gamification-enriched learning activities affected academic achievement, attitudes, and science learning skills through a quasi-experimental design.

Study Sample: The participants of the study were 6^{th} grade students from a state school in Şanlıurfa during the 2022-2023 academic year. Twenty-one students participated in the study for the experimental group, while the control group consisted of twenty-two students.

Data Collection Instruments: To assess how gamification-enriched learning activities impacted on academic achievement, attitudes towards science, and science learning skills, different data collection tools were utilized. The "Academic Achievement Test for Systems in Our Body," developed by Aksu (2019), was used to measure students' academic performance in relation to the instructional methods. The test consists of 30 multiple-choice questions (4 options) that cover topics and sub-objectives of the systems unit in the human body. The reliability of this test was reported as KR20 = .79 by Aksu (2019), and for this study, it was calculated as KR20 = .82.

The "Test of Science-Related Attitudes" (TOSRA), developed by B. J. Fraser (1978) and simplified by Chaerul (2002) and that was adapted into Turkish by Cürebal (2004) was used to measure students' attitudes towards science. The Likert type scale includes 25 items with five points had a reliability coefficient of .84, as reported by Cürebal (2004), and .81 for this study.

The "Science Learning Skills Scale (Chang et al., 2011)" was employed for assessing students' science learning skills development. The Turkish version of instrument was adapted by Şenler (2014). The instrument contains 29 items with 5 points that had an Alpha reliability coefficient reported as .93 by Şenler (2014) and calculated as .83 for this study.

Data Collection Process: The experimental process in the research was conducted over a period of 8 weeks that included 4 class hours each week. While the lessons for the control group students were taught with lesson plans prepared using the methods foreseen by the current instructional programs, the learning process in the experimental group was enriched with gamification components in addition to the current instructional programs. According to Werbach (2016), all elements within the gamification design do not have to be used simultaneously in the gamified context. A good gamification design can be achieved not by using all elements but by using the elements effectively and correctly in the gamification design. Accordingly, this study was designed using the pyramidal gamification design framework developed by Werbach and Hunter (2012). Elements from the Pyramidal Design Model, such as badges, collections, leaderboards, and rewards, were adapted to the level of sixth-grade students. Pilot studies were conducted on how the application process would be carried out, how to earn badges, create collections, use the Plickers application, and create a leaderboard.

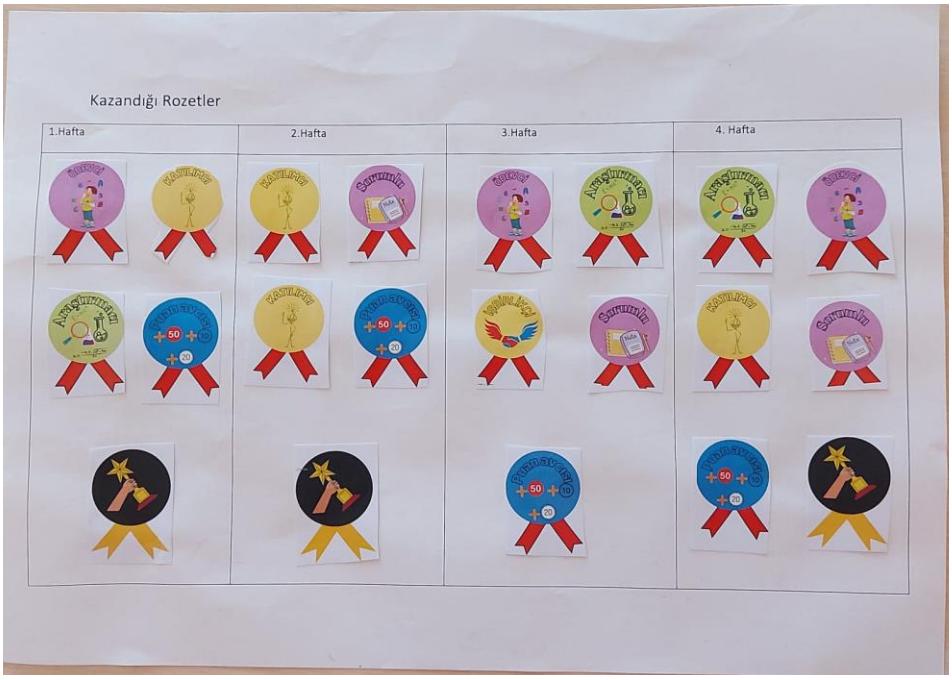
While the badges, collections, and leaderboard from gamification components were included in the lesson plans every week, the reward element was used in two stages during the application process. Badges, one of the most frequently used and effective elements of games, are visual elements obtained or representing the situation achieved as a result of the players' successes in the game (Bozkurt & Genç-Kumtepe, 2014). Badges are one of the elements that provide learners with the opportunity to track their progress and are seen as a status symbol among learners (Karamert, 2019). In this study, badges were used as an encouraging element for students to track their own progress. The badge system used in the gamification system was designed to be obtainable by learners based on the tasks they would perform weekly (table 1). The badges used in the research were developed using the Canva application.

Table 1
The badges used in the study

• The badges are designed to be earned by students based on the tasks they complete weekly. • Each badge represents a certain number of points.		Champion  badge
Participating  badge	Investigating  badge	Responsibility  badge

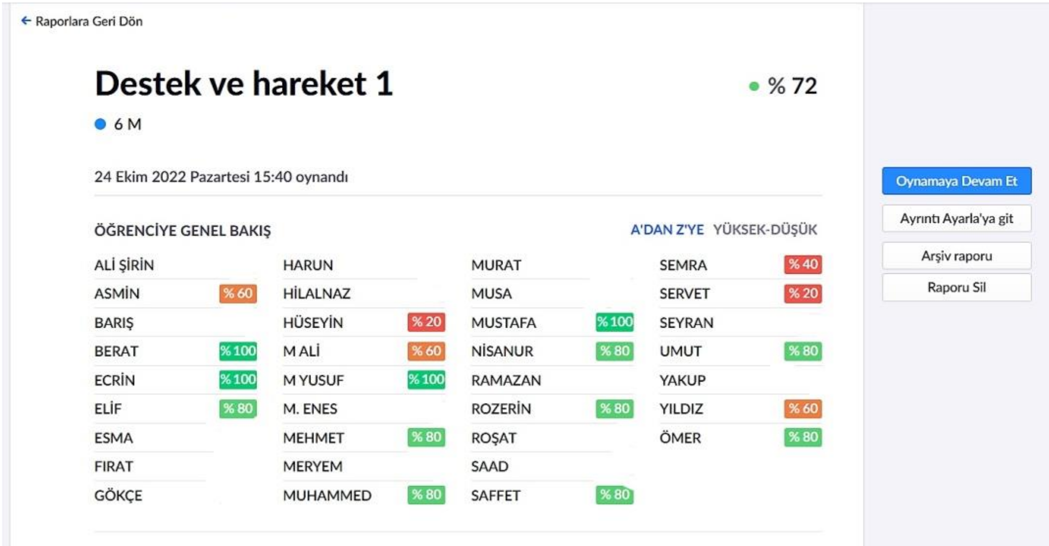
Homeworker badge	Point hunter badge	Cooperative badge
		

Collecting badges and turning them into collections is engaging and motivating for students. The desire to complete a collection encourages students to gather badges (Sever &Bical, 2018). In this context, the research included collections to encourage students to accumulate badges (picture 1).



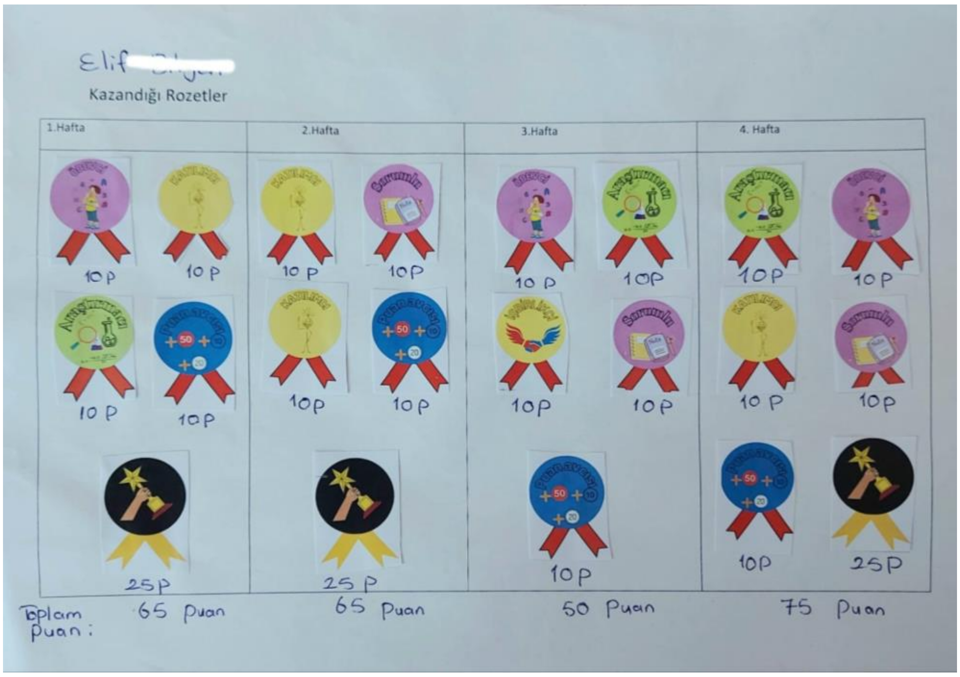
Picture1. *Example of collection table 1*

The leaderboard is one of the game components used to show the point differences between players, encourage competition, increase motivation, and make the game experience more engaging (Nicholson, 2015). Leaderboards are typically organized as a list or graph showing the highest scores, achievements, or progress and are updated based on a specific time period or game session (picture 2). In his study, Nicholson (2015) stated that the unplanned use of leaderboards could negatively affect the motivation of students with lower achievement levels. To capture the interest of all students, leaderboards created through question-solving were developed using the Plickers application, ensuring that the questions were at a level that all students could solve.



Picture 2. *Example of leaderboard*

During the implementation process of the research, the reward element was used in two stages. In the first stage, to motivate students and help them focus on the process, students who participated in the question-solving activities on the Plickers application and other in-class activities earned the right to receive a reward at the end of the second week. In the second stage of the reward element, the points accumulated from the badges collected in the student's collection were totalled (picture 3). Students who reached 400 points earned the right to receive a reward. In this context, the focus was on the student's personal development rather than competition among students. Care was taken to ensure that the rewards earned were tools and materials to be used in class.



Picture 3. *Badge scoring system*

Data Analysis: The data collected in the study was analyzed using SPSS.23 (Statistical Package for the Social Sciences) software. In order to observe the changes in the pre-test and post-test score averages of both experimental and control groups, Split-plot ANOVA test, which enables the analysis of variance within groups and can also determine whether there is a significant difference between groups, was applied. In the results of the analysis, the effect size (η^2) value was also examined in addition to the p value for significant differentiation. Effect size tests the reliability of the relationship between the dependent variable and the independent variable (Tabachnick & Fidell, 2005). In the interpretation of the effect size, the effect size values determined by Cohen (1988) as small (η^2=0.01), medium (η^2=0.06) and large (η^2=0.14) for ANOVA analyzes were taken into consideration.

Findings

The statistical analysis of mean and standard deviation values of the control and experimental groups are provided in table 2.

Table 2
The control and experimental groups' mean and standard deviation values

		Control Group			Experimental Group		
		N	Mean	SD	N	Mean	SD
Academic achievement	Pre-test	22	8.68	3.09	21	8.04	2.35
	Post-test	22	12.63	4.52	21	17.9	5.41
TOSRA	Pre-test	22	3.51	.459	21	3.69	.287
	Post-test	22	3.4	.457	21	3.75	.334
Science learning skills	Pre-test	22	3.25	.39	21	2.9	.381
	Post-test	22	3.19	.356	21	3.4	.39

The results in table 2 displays that the average post-test academic achievement, attitudes towards science and science learning skills scores of the experimental group students were higher than those of the control group students. In order to statistically test the effect of the applied program on the academic achievement, attitudes towards science and science learning skills of the participants in the experimental group, the scores obtained from the pre-test and post-test were analyzed using Two-Factor Analysis of Variance for mixed designs (split-plot) (Table 3).

Table 3
2x2 Split-plot ANOVA results for pretest-posttest scores of experimental and control group students' academic achievement, attitude towards science and science learning skills

		Sum of Squares	df	Mean Square	F	p	η^2
Academic Achievement	Between Groups (E/C)	115.3	1	115.3	5.34	.026	.115
	Error	885.8	41	21.6			
	Within (Pre/Post)						
	Time	1024.7	1	1024.7	95.3	.000	.298
	Group-Time	187.1	1	187.1	17.4		
	Error	440.7	41	10.7			
TOSRA	Between Groups (E/C)	1.48	1	1.48	10.1	.003	.198
	Error	6.01	41	.147			
	Within (Pre/Post)						
	Time	.018	1	.018	.108	.329	.023
	Group-Time	.16	1	.16	.976		
	Error	6.7	41	.164			

Science Skills	Learning	Between Groups (E/C)	.108	1	.108	.606	.441	.015
		Error	7.33	41	.179			
		Within (Pre/Post)						
		Time	1.05	1	1.05	9.57	.000	.265
		Group-Time	1.62	1	1.62	14.8		
		Error	4.49	41	.11			

According to Table 3, as a result of the analysis of variance conducted on the mean academic achievement pre-test and post-test scores of the students in the experimental and control groups, it is seen that the intervention effect is significant and the eta square value has a large effect size ($F_{(1,41)}$ =5.34; $p<.05$, $\eta^2=.115$). This finding shows that there is a significant difference between the pre-test and post-test academic achievement mean scores of the experimental and control groups. Likewise, it is seen that there is a significant difference between the measurements made at different times, that is, the main effect of time is also significant and the eta square value has a large effect size ($F_{(1,41)}$=95,3; $p<.01$, $\eta^2=.298$). This finding shows that the difference between the students' pre-test and post-test measurements is significant regardless of the group. In addition, the joint effect of intervention and time was also significant ($F_{(1,41)}$=17.4; $p<.01$, $\eta^2=.298$).

When Table 3 is examined, it is seen that the intervention effect is significant and the eta square value has a large effect size as a result of the analysis of variance performed on the pre-test and post-test attitude towards science mean scores of the students in the experimental and control groups ($F_{(1,41)}$ =10.1; $p<.05$, $\eta^2=.198$). This finding shows that there is a significant difference between the mean pre-test and post-test attitude towards science scores of the experimental and control groups. On the other hand, it was determined that there was no significant difference between the measurements made at different times ($F_{(1,41)}$ =.108 $p>.05$, $\eta^2=.023$). This finding indicates that the difference between the pre-test and post-test measurements of the students regardless of the group was not significant. Again, it was determined that the joint effect of intervention and time was not significant ($F_{(1,41)}$=.976; $p>.05$, $\eta^2=.023$).

According to Table 3, as a result of the analysis of variance conducted on the pre-test and post-test science learning skills mean scores of the students in the experimental and control groups, the effect of the intervention was not significant ($F_{(1,41)}$ =.606; $p>.05$, $\eta^2=.015$). This finding shows that there is no significant difference between the pre-test and post-test science learning skills mean scores of the experimental and control groups. On the other hand, there was a significant difference between the measurements made at different times, that is, the main effect of time was significant and the eta squared value had a large effect size ($F_{(1,41)}$=9.57; p<.01, η^2=.265). This finding shows that the difference between the students' pre-test and post-test measurements is significant regardless of the group. In addition, the joint effect of intervention and time was also significant ($F_{(1,41)}$=14.8; p<.01, η^2=.265).

Table 4
Analysis of Variance Results According to Repeated Measures Wilks Lambda (Λ) Statistic

	Effect	Wilk'λ	df	F	p	η^2
Academic achievement	Time	.301	1.0	95.32	.000	.699
	Time*Group	.702	1.0	17.41	.000	.298
TOSRA	Time	.997	1.0	.108	.744	.003
	Time*Group	.977	1.0	.976	.329	.023
Science Learning Skills	Time	.811	1.0	9.57	.004	.189
	Time*Group	.735	1.0	14.8	.000	.265

When the analysis of variance in Table 4 is analyzed, it is seen that academic achievement changes significantly over time and the effect size is large (Wilks' λ=.301, $F_{(1,41)}$=95.32; p<.01, η^2=.699). Likewise, it is seen that the interaction effects of time*intervention are also significant and the effect size is large (Wilks' λ = .702, $F_{(1,41)}$=17.41; p<.01, η^2 =.98). According to these findings, compared to the control group, it can be said that the academic achievement levels of the students in the experimental group changed at different rates before and after the procedure and this change was significant.

Analysis of variance revealed that attitude towards science did not change significantly over time (Wilks' λ= .997, $F_{(1,41)}$=.108; p>.01). Likewise, it was determined that the interaction effects of time*intervention were not significant (Wilks' λ = .977, $F_{(1,41)}$=.976; p>.01).

When the analysis of variance given in Table 4 is analyzed, it is seen that the science learning skill level changed significantly over time and the effect value is large (Wilks' λ=.811, $F_{(1,41)}$=9.57; p<.01, η^2=.189). Likewise, it is seen that the interaction effects of time*intervention are also significant and the effect value is large (Wilks' λ =.735, $F_{(1,41)}$=14.8; p<.01, η^2 =.265). According to these findings, it can be said that the science learning skill levels of the students in the experimental group changed at different rates before and after the intervention compared to the control group and this change was significant.

Discussion and Conclusion

The findings of the current study demonstrated that both participant group students showed an important improvement in academic success. This is usually an expected outcome of any teaching and learning process. In contrast, the study did not display any significant difference in the comparisons of pre-test and post-test attitude scores towards science for both the control and experimental group students. When means were considered, students' attitudes towards science for the control group decreased, in contrast experimental group students mean scores for the attitudes toward science increased. Attitudes towards science are directly related to interest in the subject. It can be suggested that the teaching methods used in the current program do not make learning science engaging enough. Since attitudes develop gradually over time, it is also recognized that changing them quickly is challenging. This is also supported by different reseach that found gamification activities do not contribute to a significant improvement in attitudes toward science by the end of the experimental process (Marcos et al., 2014; Kyewski & Kramar, 2018; Çayır, 2021). Çelik (2017) evaluating "our body systems" by considering the age range and cognitive development levels of the students found that the unit contained many abstract concepts, had many learning outcomes, and the textbooks had few examples related to daily life. This situation may have affected the attitudes towards science of students in both groups. At the same time, using an approach like gamification different from the methods, techniques, and approaches envisaged by the current teaching program during the teaching process may have attracted the attention of the experimental group students, aroused their curiosity, and provided them with a slightly positive attitude towards the lesson by motivating them towards it.

The present study did reveal any important difference when comparing students' test scores before and after the experimental process for science learning skills in the control group, while their science learning skills decreased at the mean level. However, experimental group students' science learning skills significantly increased when the experimental process ended. This may be due to the fct that the development of science learning skills is closely related to activities such as doing, solving, and discussing science. It is thought that gamification activities providing students with opportunities for discussion and problem-solving led to this outcome.

The findings of the study displayed statistically important differences, when the two participant groups were compared, favouring the of the experimental group for academic achievement in the students' scores after the instructional process. This result suggests that gamified learning is effective in increasing academic success. Different studies have documented that teaching with gamification increases student success (Kumar & Khurana, 2012; Karayılan Tunç, 2019; Pechenkina et al., 2019; Zhan et al., 2022). Teachers and students state that gamification activities increase course success (Rincon- Flores & Santos- Guevara, 2021). Akkaya (2020) found a significant increase in academic achievement among students learning with gamification elements. Considering that people today spend a significant amount of time playing games and even postpone their most basic needs while playing, integrating a well-designed gamification design into the education process can be seen as interesting by students. It is expected that these applications will increase learners' motivation (Yıldırım & Karahan, 2023), create a positive learning environment (Zhan et al., 2022), facilitate peer learning (Wang, 2023), and thus increase participation in the lesson and academic achievement.

The study found important diffrences when comparing the pariticipant students' test scores before and after the instrucrional activities that included gamification. Students in the experimental group displaying higher scores for attitudes towards science. In this context, it can be said that gamified learning increases attitudes towards science. In the literature, there are studies showing that gamification activities increase attitudes towards science (Yılmaz, 2019; Karagöz, 2023) and studies showing that it does not affect attitudes towards science (Akkaya, 2020; Karamert, 2019; Şahin, 2022). Yılmaz (2019), in his study in the science course, found that gamification activities increased attitudes towards science. Zourmpakis et al. (2023) aimed to describe the motivational effect of using gamification environments in science education. The study concluded that students were more motivated to learn science while using an adaptable game environment and found traditional methods boring, whereas they liked the game elements integrated into science lessons. Bozkurt and Genç-Kumtepe (2014) describe gamification as an innovative approach that provides active participation in the learning process and increases motivation, making the learning process more enjoyable, effective, and efficient, and creating commitment to the teaching process. Ar (2016), Bozkurt, and Genç-Kumtepe (2014) found that gamification applications contributed to students feeling successful during the teaching process, having fun while learning, enjoying it, and wanting to use gamification in other units and lessons as well.

The comparison of students' achievement scores prior to and after the instructional process for the control group displayed a considerable improvement in academic performance. Similarly, students in the experimental group also showed significantly higher post-test scores compared to their pre-test scores, which is a natural and expected outcome of the learning process.

However, when comparing students' attitude scores toward science, no significant difference was observed in the control group. Likewise, the experimental group showed no significant changes in their attitude scores. On average, the control group students' attitudes toward science slightly declined, while the experimental group showed a slight increase. Since attitudes are closely tied to interest in the subject and develop over a long period, changing them in a short time can be challenging. This outcome suggests that the current program's teaching elements may not sufficiently engage students or make learning science enjoyable. Similar studies on gamification by Marcos et al. (2014), Kyewski and Kramar (2018), and Çayır (2021) also found no significant increase in attitudes toward science. Çelik (2017) pointed out that certain units, such as those evaluating the body's systems, contain many abstract concepts and few examples from daily life, which might have influenced students' attitudes toward science. Gamification, which differs from traditional teaching methods, may have piqued the experimental group's curiosity and slightly improved their attitude toward the lesson.

The current study did not find any important change when the control students' science learning scores for the test used before and after the experimental instructional process were compared. In contrast, the experimental group showed a significant improvement in their science learning skills by the end of the experiment. This increase is likely related to activities like problem-solving and discussion, which were facilitated by the gamification elements used in the teaching process.

The findings show an important difference when the experimental and the control group students' post-test academic achievement scores were compared, favoring the experimental group. This suggests that gamified learning is effective in improving academic achievement. Studies by Araya et al., Kumar and Khurana (2012), Karayılan Tunç (2019), Pechenkina et al. (2019), and Zhan et al. (2022) similarly concluded that gamification enhances student success. Teachers and students have also noted that gamification boosts course success (Rincon-Flores & Santos-Guevara, 2021). Akkaya (2020) found a significant increase in academic performance in the "Interaction of Light with Matter" unit when gamification elements were used. Since people today spend considerable time playing games, integrating well-designed gamified elements into education can be engaging for students, enhancing their motivation, fostering a positive learning environment (Yıldırım & Karahan, 2023), supporting peer learning (Wang, 2023), and boosting both participation and academic achievement.

Additionally, the study findings show important differences in students' post-test scores for attitudes toward science when comparing the participant groups. Students in the experimental group groupdisplayed more positive attitudes towards science. This suggests that gamified learning can improve students' attitudes toward science. Studies in the literature present mixed results, with some showing that gamification positively influences attitudes toward science (Yılmaz, 2019; Karagöz, 2023), while others (Akkaya, 2020; Karamert, 2019; Şahin, 2022) do not documentany effect. Yılmaz (2019) suggests that gamification activities, such as games played using QR codes, improved attitudes toward science. Zourmpakis et al. (2023) examined the motivational impact of using gamified environments in science education. The study found that it was easier to motivate students for learning in these environments, while traditional methods were considered dull. They appreciated the game elements integrated into their science lessons. Bozkurt and Genç-Kumtepe (2014) describe gamification as an innovative approach that encourages active participation, motivate students, and renders the learning activities enjoyable, effective, efficient and fosters a sense of commitment. Studies by Ar (2016), Bozkurt, and Genç-Kumtepe (2014) found that gamification applications help students feel successful, have fun while learning, and wish to see gamification applied in other units and subjects.

Prior to the experimental process, there was a significant difference in science learning skills between the control and experimental groups, with the control group performing better. However, after the experimental process, no significant difference was found between the two groups. By the end of the experiment, the control group's science learning skills had decreased on average, while the experimental group's skills had improved. The use of gamification components, such as badges and leaderboards, likely contributed to this improvement. The participation badge encouraged active engagement in the lessons, the responsibility badge ensured students completed their tasks on time, the collaboration badge promoted teamwork and peer communication, and the research badge required students to investigate problem situations and find solutions. These challenges encouraged students to think critically and solve problems, which likely contributed to the improvement in science learning skills among the experimental group.

Additionally, this study did not reveal any considerable difference regarding male and female students' academic success for the experimental group. This aligns with previous research in the field (Clark et al., 2011; Brom et al., 2011), which suggest that digital games appeal to people of all ages, genders, and professions. Similarly, gamification activities are likely to engage both male and female students equally, leading to comparable levels of success in gamified teaching environments.

Recommendations

Based on the study's findings, the following recommendations are proposed:

- Science teachers should receive in-service training on gamification design, the use of gamification components, and Web 2.0 gamification applications.
- The Education Informatics Network (EBA) should be enriched with lesson materials that incorporate various gamification elements.
- Relevant learning outcomes should be added to the national science curriculum to support the integration of technology into education.

References

Abramovich, S., Schunn, C. & Higashi, R. M. (2013). Are badges useful in education? It depends upon the type of badge and expertise of learner. *Educational Technology Research and Development*, *61*(2), 217-232.

Ağırgöl, M., Kara, E., & Dönel Akgül, G. (2022). The effect of science lesson taught with educational digital games on student retention of knowledge, academic success and attitudes]. International Journal of Science and Education, *5*(3), 157-176. https://doi.org/10.47477/ubed.1063920

Akkaya, S. (2020). The effects of Plickers application on the academic achievements of the seventh grade students in the science course and their attitudes towards the course. Master's Thesis, Ordu Universty, Ordu.

Aksu, İ. (2019). *The Effect of Use of Songs with Teaching Material in Science Course on Students' Success, Attitude and Retention.* Master's thesis, Van YüzüncüYıl University, Van.

Ar, N. A. (2016). *The effects of gamification on academic achievement and learning strategies usage of vocational high school students.* Master's Thesis, Sakarya University, Sakarya.

Araya, R., Arias Ortiz, E., Bottan, N. L. &Cristia, J. P. (2019). Does Gamification in Education Work?: Experimental Evidence from Chile. Inter-American Development Bank.

Bereiter, C., & Scardamalia, M. (1989). Intentional learning as a goal of instruction. In L. B. Resnick (Ed.), Knowing, learning, and instruction: Essays in honor of Robert Glaser (pp. 361-392). *Hillsdale, NJ: Lawrence Erlbaum Associates.*

Bozkurt, A., & Genç-Kumtepe, E. (2014). Gamification, game philosophy and education: Gamification. *Academic Informatics*, *14*, 147-156.

Brom, C., Preuss, M. & Klement, D. (2011). Are educational computer micro games engaging and effective for knowledge acquisition at high-schools? *A quasi experimental study. Computers& Education*, 57, 1971-1988.

Chaerul, A., (2002). *A study of student attıtudes toward physics and classroom environment based on gender and grade level among senior secondary education students in Indonesia*. Unpublished Doctoral Thesis, State University, New Mexico.

Chang, H.-P., Chen, C.-C., Guo, G.-J., Cheng, Y.-J., Lin, C.-Y., & Jen, T.-H. (2011). The development of a competence scale for learning science: Inquiry and communication. *International Journal of Science and Mathematics Education*, 9(5), 1213–1233

Chinn, C. A., & Brewer, W. F. (1993). The role of anomalous data in knowledge acquisition: A theoretical framework and implications for science instruction. *Review of educational research*, *63*(1), 1-49.

Clarck, D. B., Nelson, B. C., Chang, H., Martinez-Garza, M., Slack, K. & D'Angelo, C.M. (2011). Exploring Newtonian mechanics in a conceptually-integrated digital game: *Comparison of learning and affective outcomes for students in Taiwan and the United States. Computers& Education*, 57, 2178-2195.

Cohen, J. (1988*). Statistical power analysis fort hebehavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Cürebal, F. (2004). *Gifted students' attitudes towards science and classroom environment based on gender and grade level.* Unpublished Master's Thesis, ODTÜ, Ankara.

Çayır, M. (2021). *The effect of gamification approach on attitude and academic success in reading and writing skills of turkish course*. Master's Thesis, Amasya University, Amasya.

Çelik, Ö. (2017). *Evaluation of the science subject for 6th grade curriculum in middle school in terms of the systems in our body: Konya sample.* Unpublished Master's Thesis, Necmettin Erbakan University, Konya.

Çinici, A., Özden, M., Akgün, A., Herdem, K., Deniz, Ş. M., & Karabiber, H. L. (2014). Investigating the effectiveness of argumentation-based activities supported with concept cartoon. *Adiyaman Universityjournal of Social Sciences*, (18), 571-596.

De-Marcos, L., Domínguez, A., Saenz-de-Navarrete, J. & Pagés, C. (2014). An empirical study comparing gamification and social networking on e-learning. *Computers & Education*, 75, 82-91.

Deterding, S., Khaled, R., Nacke, L. E. & Dixon, D. (2011). Gamification: Toward a definition. *CHI 2011 Gamification Workshop Proceedings*, 12-15.

Dicheva, D., Dichev, C., Agre, G. & Angelova, G. (2015). Gamification in education: A systematic mapping study gamification in education: A systematic mapping study. *Educational Technology and Society,* 18, 75–88.

Fleischmann, K. & Ariel, E. (2016). Gamification in Science Education: Gamifying Learning of Microscopic Processes in the Laboratory. *Contemporary Educational Technology, 7*(2), 138-159.

Gee, J. P. (2005). Good video games and good learning. *Phi Kappa Phi Forum*, *85*(2), 33–37.

Hayırsever, F., & Orhan, A. (2018). A Theoretical Analysis of Flipped Learning. *Mersin University Journal of the Faculty of Education, 14*(2), 572-596.

Hancock, C., Kaput, J. J., & Goldsmith, L. T. (1992). Authentic inquiry with data: Critical barriers to classroom implementation. *Educational Psychologist, 27*(3), 337–364.

Ilgaz, G. (2006). *The attitudes of seventh grade towards the science course and learning strategy use.* Master's Thesis, Trakya University, Edirne.

Kapp, K. M. (2012). *The gamification of learning and instruction: game-based methods and strategies for training and education.* John Wiley & Sons.

Karagöz, M. (2023). The effect of gamification supported by Web 2.0 tools on students' course success and attitudes towards the course in science course. Master's Thesis, Kütahya Dumlupınar University, Kütahya.

Karamert, Ö. (2019). The effect of gamification on the success and attitude of the 5th grade mathematics course, Master's thesis, Düzce University, Düzce.

Karayılan Tunç, M. (2019). *Effects of the elements of gamification on science success and retention: reproduction, growth and development in plants and animalsunit.* Unpublished Master's thesis, Dicle University, Diyarbakır.

Kumar, B. & Khurana, P. (2012). Gamification in education-learn computer programming with fun. *International Journal of Computers and Distributed Systems, 2*(1), 46-53.

Kyewski, E., & Krämer, N. C. (2018). To gamify or not to gamify? An experimental field study of the influence of badges on motivation, activity, and performance in an online learning course. *Computers & Education,* 118, 25-37.

Lee, J. J. ve Hammer, J. (2011). Gamification in education: What, how, why bother? *Academic Exchange Quarterly,* 15(2), 146.

Nicholson, S. (2015). A RECIPE for Meaningful Gamification. In Wood, L. & Reiners, T., eds. *Gamification in Education and Business*, New York: Springer. 1-20.

Potts, A., Schlichting, K., Pridgen, A., & Hatch, J. (2010). Understanding new literacies for new times: Pedagogy in action. *International Journal of Learning,* 17(8), 187- 194.

Pechenkina, E., Laurence, D., Oates, G., Eldridge, D., & Hunter, D. (2017). Using a gamified mobile app to increase student engagement, retention and academic achievement. *International Journal of Educational Technology in Higher Education, 14*(1), 31.

Rincon-Flores, E. G., & Santos-Guevara, B. N. (2021). Gamification during Covid-19: Promoting active learning and motivation in higher education. *Australasian Journal of Educational Technology*, *37*(5), 43–60.

Rouse, K. E. (2013). *Gamification İn Science Education: The Relationship of Educational Games to Motivation and Achievement* (Ph. D.). The University of Southern Mississippi. Ann Arbor.

Sever, S. & Bical, A. (2018). Use of game elements in gamification: a case study on adidas micoach, khan academy, superbetter and swarm applıcatıons. *Journal of Erciyes Communication, 5*(3), 216-236.

Schauble, L., Glaser, R., Duschl, R. A., Schulze, S., & John, J. (1995). Students' understanding of the objectives and procedures of experimentation in the science classroom. *Journal of the Learning Sciences, 4*(2), 131–166.

Stamovlasis, D., Dimos, A., &Tsaparlis, G. (2006). A study of group interaction processes in learning lower secondary physics. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *43*(6), 556-576.

Singer, J., Marx, R. W., Krajcik, J., & Clay Chambers, J. (2000). Constructing extended inquiry projects: Curriculum materials for science education reform. *Educational Psychologist*, *35*(3), 165-178.

Şahin, F. (2022). *The effects of the use of Learnıngappsapplıcatıon in the 7 th grade scıence course cell and dıvısıonsunıt on students achıevement and attıtudes towards the course*. Master's thesis, Ordu University, Ordu.

Şenler, B. (2014). Turkish Adaptation of the Competence Scale for Learning Science: Validity and Reliability Study. *Journal of Theory and Practice in Education,* 10(2): 393-407.https://doi.org/10.17244/eku.00515

Turkish Language Association. (2019). Turkish Dictionary.http://tdk.gov.tr, erişim: 2023.

Ulus, G. (2021).*The effect of using gamification on students' academic achievement and motivation for matter and change unit.* Master's thesis, Dokuz Eylül University, İzmir.

Uskan, S. B. & Bozkuş, T. (2019). Place of play in education. *International Journal of Contemporary Educational Studies (IntJCES),* 5 (2), 123-131.

Vellom, R. P., & Anderson, C. W. (1999). Reasoning about data in middle school science. *Journal of Research in Science Teaching, 36*(2), 179–199

Wang, Y. C. (2023). Gamification in a News English Course. *Education Sciences*, *13*(1), 90.

Werbach, K. (2016). *Gamification. Class Lecture, Topic: "Gamification Design Framework"* Coursera.

Werbach, K. ve Hunter, D. (2012). *For the win: How game thinking can revolutionize your business.* Wharton Digital Press.

Yore, L. D. (2008). Science literacy for all students: Language, culture, and knowledge about nature and naturally occurring events. *L1-Educational Studies in Language and Literature*, 5-21.

Yore, L. D., Florence, M. K., Pearson, T. W., & Weaver, A. J. (2006). Written discourse in scientific communities: A conversation with two scientists about their views of science, use of language, role of writing in doing science, and compatibility between their epistemic views and language. *International Journal of Science Education*, *28*(2-3), 109-141.

Yildirim, L., & Karahan, E. (2023). Effect of Web 2.0 Gamification Tools on Listening Comprehension Skills in a Second Foreign Language German Course. *Digital Education Review*, *43*, 37-67.

Yılmaz, B. (2019). *The effect of qr code-based games with astronomy concepts toward attitudes of the 7th grade students to science and technologhy.* Unpublished Master's thesis, Aksaray University, Aksaray.

Zhan, Z., He, L., Tong, Y., Liang, X., Guo, S., & Lan, X. (2022). The effectiveness of gamification in programming education: Evidence from a meta-analysis. *Computers and Education: Artificial Intelligence*, 100096.

Zichermann, G. & Cunningham, C. (2011). *Gamification by design: Implementing game mechanics in web and mobile apps.* O'Reilly Media, Inc.

Zourmpakis, A-I, Kalogiannakis, M & Papadakis, S. (2023). Adaptive gamification in science education: An analysis of the ımpact of ımplementation and adapted game elements on students' motivation. *Computers*. *12*(7), 143.

URL-5,https://ibrahimbati.com/egitim/plickers-nedir.html. Access date: 12 September 2023.