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Original Article

The Effect of Gamification and Uncertainty in Rewards on Elementary School Students: A Quasi-Experimental Study

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ABSTRACT

Background: Gamification is an effective, dynamic, and engaging educational approach which makes the learning process more interactive for participants. This study aims to investigate the impact of gamification and the type of rewards on the learning outcomes of sixth-grade students in Karaj City in 2021.

Methods: This study employs a quasi-experimental pre-test and post-test design featuring two experimental groups and a control group. The statistical population includes all sixth-grade students in Karaj schools who were studying in November 2021. Eighty-four participants were selected using convenient sampling and then randomly (simple random) assigned to three groups. The first experimental group (n=32) was taught using gamification, which included an element of uncertainty in rewards, and the second experimental group (n=31) was taught with gamification, which included fixed rewards. Conversely, the control group (n=21) used e-learning without gamification. The data collection utilized a 20-item questionnaire developed as an expert-validated learning test with confirmed reliability. The collected data were analyzed using covariance analysis with IBM SPSS v 26. Descriptive statistics were used to report quantitative findings.

Results: The Mean±SD scores for learning outcomes in experimental group 1 were 9.43±3.79 and 14.14±3.52 in the pre- and post-tests, respectively. In experimental group 2, the Mean±SD scores for learning outcomes were 9.85±3.01 and 13.65±3.11 in the pre- and the post-tests, respectively. In the control group, the Mean±SD scores for learning outcomes were 8.47±3.05 and 10.85±4.04 in the pre- and the post-tests, respectively. The results indicate that gamification significantly affects learning (P=0.003). Both gamification groups outperformed the control group in learning outcomes. Despite a higher mean score in the uncertain rewards group, there was no significant difference between the two experimental groups.

Conclusion: Gamification, regardless of the reward type, seems to positively impact students' learning. Therefore, educators and e-learning designers are encouraged to implement gamification strategies, including elements of uncertainty and chance, to enhance learning experiences in elementary schools.

Keywords: E-learning, Gamification, Learning, Reward

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Introduction

In recent years, the practice of incorporating game elements into educational environments, known as gamification, has gained traction and is being used to enhance engagement and foster interactive learning experiences. Gamification involves using game elements in non-game contexts to achieve specific objectives (1). It can be applied in various areas such as marketing, sales, healthcare, or education. Gamification has proven to be effective in enhancing the learning experience within the education sector (2) and has also been successfully implemented in e-learning platforms (3). As a result, various researchers have investigated the use of educational games and gamification, with findings indicating that gamification is effective for learning (4-8), motivation (9), academic engagement (10, 11), and students' performance (12).

For instance, research has demonstrated that gamification is effective in face-to-face classroom settings (4) and that incorporating educational games can enhance learning and knowledge retention in elementary school students, particularly in the subject of social studies. Additionally, the use of gamification in various e-learning environments has been shown to positively impact various learning outcomes, as evidenced by studies (4-6). Furthermore, the findings indicate that combining e-learning with innovative approaches such as flipped learning enhances the effectiveness of these methods (7).

Furthermore, extensive research consistently indicates that gamification positively affects learning across various subjects. Specifically, gamification has been found to enhance English language learning significantly. For instance, some studies have demonstrated the effectiveness of gamification in improving seventh-grade English language learning (8) and enhancing vocabulary acquisition and retention for English language learners (13). Moreover, gamification has also shown promising results in statistics education. Research has revealed the positive impact of challenge-based gamification on student learning outcomes in the School of Electrical and Computer Engineering (14).

Moreover, gamification has been found to impact various processes related to learning, including learner performance, engagement, and motivation. In this regard, a study (12) shows that gamification in the online computer architecture course resulted in higher grades for the gamification group compared to the control group, indicating a statistically significant difference in students' performance on post-test scores. Furthermore, the implementation of gamification has proven to be effective in bolstering motivation (9) and engaging learners (10, 11).

Gamification is often associated with rewards. In electronic environments, gamified systems emphasize elements like points, leaderboards, badges, and levels to encourage participation and reward attainment. Rewards have been used for centuries to influence behavior (15). When gamification is used, game components are added to common work processes to persuade the user; therefore, the internal motivations of users that encourage and motivate them to participate in gamification processes are necessarily linked to external rewards (16). This internal and external motivation and participation of learners leads to their engagement in the activity, and when gamification is used in educational environments, learners' academic engagement is impacted. Learning can be enjoyable when we integrate elements of games, which are inherently rewarding, with the learning process. This approach encourages students to learn through play, promoting curiosity, success, enjoyment, and engagement in the learning experience, as well as better mental preparedness for learning (3).

Gamification leads to cognitive, emotional, and behavioral engagement of the learner, and this academic engagement leads to learning efficiency. According to Prensky (17), the learning approach of today's digital generation is the "engage me" approach. Prensky emphasizes that "learning based on digital gamification" can be a good central

learning approach for today's generation. So, if we can integrate gamification elements into educational situations, we can get one step closer to the learner-centered approach.

However, one of the challenges of e-learning is creating an engaging and motivating environment for students, and one way to achieve this goal is to use gamification. The main goal of gamification is to increase user motivation, experience, and participation. Therefore, gamification has become a popular approach in the e-learning industry because it effectively attracts learners and enhances both the enjoyment and effectiveness of the learning process.

Simões and colleagues found that gamification in e-learning can promote motivation, stimulate interest in learning, and engage learners in learning (18).

Gamification can be used for different audiences and subjects, especially in primary education, where children are interested in games. Games are crucial in everyone's life, and success or failure in this area can profoundly impact their future. Experimental science is particularly challenging for students due to its complexity (19). Hence, replacing conventional and outdated teaching methodologies with dynamic and adaptable approaches that incorporate innovative educational technologies is imperative. E-learning, advocated by information and communication technology, offers prospects for self-directed learning, diverse teaching styles, and content creation in various formats. Therefore, active methods such as gamification need to be explored and tested in different situations, including the widespread use of e-learning today.

Using gamification requires careful design, as its effectiveness cannot be guaranteed by using arbitrary methods and media. The way the media is designed is critical (20). Points are an essential element in games, and how they are presented is an interesting topic in the field (21). Kapp points out that it is essential to understand how the incentive structure works and how it can be integrated into the game. Receiving and viewing scores by players is a strong motivator to play the game repeatedly. It allows players to socialize and discuss the game and the highest scores. This also gives social capital and rights to those with the highest scores. Points can be awarded in various ways, including scoring, collecting coins, accessing advanced weapons, or gaining more power (22).

Skinner introduced the concept of the variable ratio reinforcement schedule, which is used in many games to keep players engaged over time (23). This concept means that behavior is reinforced in an unpredictable ratio. For instance, eating a mushroom may sometimes result in receiving gold coins; sometimes, it may not. The player never knows if killing the last enemy will get him to the next level, and he may have to kill ten or more enemies to get to the next level. In contrast, a fixed-ratio schedule gives a certain number of points, such as a bonus for collecting 100 gold coins or badges. Using fixed-ratio reinforcement gives the feeling that the initial behavior is not encouraged, so there is little inclination to perform the behavior initially. Nevertheless, players will play the game quickly to obtain the reward (22). The motivation derived from educational games may be significantly influenced by the uncertainty of the game reward. Research conducted with children ages 10 to 11 on a simple math game showed that most players preferred the random and uncertain reward type, and this preference increased during play (24).

Accordingly, it is necessary to investigate the use of gamification in e-learning for elementary school students. As far as we know, few studies have addressed the impact of using gamification in e-learning on elementary students' learning. The design of gamification scores has also not been studied. Therefore, the main objective of this study is to investigate the impact of gamification and reward type on students learning. Consequently, the research questions are as follows:

• How does the employment of gamification with uncertain rewards impact students' learning?

• How does the employment of gamification with fixed rewards impact students' learning?

• What is the disparity in learning outcomes when employing gamification with uncertain rewards, gamification with fixed rewards, and conventional methods?

Methods

Study Design and Setting

A pre-test/post-test design was employed to assess the impact of gamification and different types of rewards on the learning outcomes of sixth-grade students in Karaj City, located near Iran's capital, in November 2021. The selected educational institution was one of the public schools that offers tuition-free education to students in Iran.

The pre-test established participants' learning levels, and comparisons of pre-test and post-test scores enabled the identification of any changes and improvements resulting from the interventions.

The quasi-experimental design was chosen to allow for comparisons between multiple experimental groups by carefully controlling variables and ensuring consistent intervention implementation. It ensured similar conditions among groups except for the independent variable and facilitated valid comparisons between the experimental groups. The details of the research design are presented in Table 1.

Participants and Sampling

The research employed convenience sampling due to the necessity of selecting a school that met specific criteria, including willingness to implement the research plan and having at least three sixth-grade classes, which was not met by all schools in Karaj. Finally, 102 students were assessed for eligibility, and in the next step, 94 students met the entry criteria. Following the sampling, a sample of 94 students was randomly assigned to both the experimental and control groups. Initially, it was determined that there would be two experimental groups, the first with 34 students and the second with 33 students, receiving gamification with uncertain and fixed rewards, respectively. Subsequently, the control group comprised 27 students who received e-learning without gamification. Cohen's tables (25) were consulted to determine the appropriate sample size for each gamification group, revealing a requirement of 30 participants per group, with an alpha level of 5 percent, an effect size of 0.05, and a power of 99. Additionally, random assignment was employed to minimize bias and ensure result validity, ensuring that any differences observed in outcomes were attributable to the instructional interventions rather than pre-existing participant characteristics.

In this study, all participants were required to be sixth-grade students of an elementary school in Karaj, Iran, who were studying in November 2021. They were exclusively male to minimize the potential influence of gender as a confounding variable. It was necessary for participants not to have any specific illnesses or disabilities that could significantly impact their ability to engage in the study. Moreover, participants should have had no serious academic problems or learning difficulties that could have hindered their effective participation. Voluntary agreement to attend all class sessions and assessments throughout the study period was also expected from participants. Those who were unwilling to continue their cooperation were excluded from the study.

Table 1: The details of the research design

Variable	Pre-test	Independent variable	Post-test
Gamification with uncertainty in rewards	T_1	X1	T_2
Gamification with fixed rewards	T_1	X2	T_2
Control group	T_1	X3	T_2

T1: Learning pre-tests; T2: Learning post-test ; X1: Uncertainty in rewards; X2: Fixed rewards; X3: Conventional methods.

Participants who answered less than 20% of the questions or did not intend to continue participating were excluded from the study. Figure 1 shows the details of participants' recruitment.

Teaching Interventions

Initially, all three study groups underwent a pretest to assess their baseline level of learning. This pretest consisted of questions derived from the science textbook. After completing the pretest, all three study groups received e-learning through the *Shad* social learning network. The *Shad* application was launched following the coronavirus outbreak in Iran, as students could not attend school. *Shad* is a social network-based application managed under the supervision of the Ministry of Education of Iran, exclusively accessible to teachers, students, and their parents. It is available both as a mobile application and via web access. In the two intervention groups, gamification was implemented as a teaching method, while the control group received e-learning without the gamification intervention.

Control Group: Pre-tests were initially conducted, and then the lessons were instructed through recorded videos based on the textbook. The videos included text analysis, answering book questions, activities, and experiments. After that, students watched all the videos and engaged in discussions within their respective groups regarding the taught topic. Question-and-answer sessions were conducted with the students. Finally, after completing the instructional sessions, a post-test was administered.

Intervention Group 1 (Gamification with uncertain rewards): Pre-tests were initially conducted, and then lessons were taught through recorded videos based on the textbook. The videos included text analysis, answering book questions, activities, and experiments. After that, students watched all the videos and engaged in discussions within

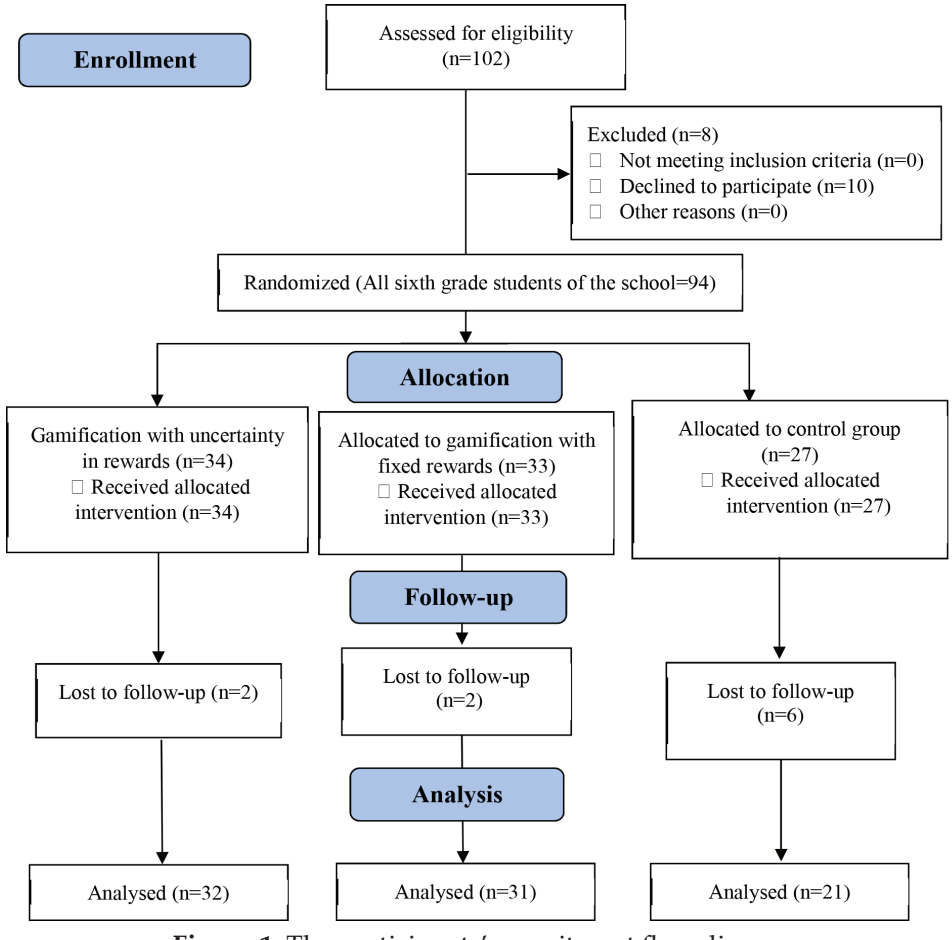

Figure 1: The participants' recruitment flow diagram

their respective groups regarding the taught topic. In this group, a game was played during six instructional sessions over two weeks. Each game session lasted 20 minutes, and students had to answer five important questions related to the lesson or text within 20 seconds per question. Those who answered correctly were awarded a score based on a chance selection between 100 and 300. Group leaders selected a number from 1 to 3, determining the score. This added an element of uncertainty and excitement to the reward system, as students could not predict the exact score they would receive for their correct answers. Score sheets were returned to the bags for the next group. Ultimately, the group with the highest points was declared the winner and received a reward or incentive points. Finally, a post-test was administered after the intervention.

Intervention Group 2 (Gamification with Fixed Rewards): Pre-tests were conducted initially, and then lessons were taught through recorded videos based on the textbook. The videos included text analysis, answering book questions, activities, and experiments. After that, students watched all the videos and engaged in discussions within their respective groups regarding the taught topic. Like intervention group 1, this group played a game during six instructional sessions over two weeks. Students had to answer questions within 20 seconds, and those who answered correctly were awarded 200 points. At the end of the questioning, winners were announced and received incentive points. Finally, a post-test was administered after the intervention. Gamification with variable scoring methods in the *Shad* application is illustrated in Figure 2.

Tools/Instruments

Data were collected using a test created by the researcher, which included 20 True/False and multiple-choice questions based on the 3 chapters from the sixth-grade experimental science book. The test covered topics such as earthquakes and their causes and effects, seismic waves, movement of the Earth's crust and its fractures, the structure and types of volcanoes, and the benefits and harms of volcanic activity.

Validity and Reliability - The content validity of the questionnaire was calculated using the Content Validity Ratio (CVR) method by 10 teachers, and the result showed an agreement coefficient of 90%. Furthermore, the reliability coefficient of the questionnaire was obtained using the Kuder-Richardson test, which was 0.79, indicating the desirable reliability of the questionnaire.

Data Collection

Given that the current research was conducted during the COVID-19 pandemic,

Figure 2: The screenshots of gamification with variable scoring methods

the pre-test and post-test were administered electronically in 2021 via Google Forms. Teachers provided students with the designed test links and guided them on how to submit their responses.

Data Analysis

To address the research questions, an analysis of covariance (ANCOVA) was utilized. Pre-test scores were used as a covariate to control for any pre-existing group differences. The analysis was conducted using the SPSS version 26 software. Descriptive statistics were also employed to summarize the quantitative findings.

Ethics – All the participants were initially briefed about the study's goals and were provided informed consent to take part. They were free to leave the investigation at any point if they no longer wished to collaborate. Upon completion of the research, participants gained access to the training methods used by other groups. The data was kept confidential throughout the study and the research project was approved by the Islamic Azad University, Science and Research Branch, Tehran, Iran.

Results

Demographic Characteristics

Table 2 presents the demographic characteristics of the participants, including age and gender. The sample consisted of sixth-grade male students with similar socioeconomic and educational backgrounds.

The mean and standard deviation of the age of the first experimental group was 12.12±0.34, the second experimental group was 12.12±0.33, and the control group was 12.14±0.35. The variance analysis showed no significant difference in age between the three studied groups.

Main Statistical Findings

Descriptive statistics (Table 3) and the paired samples t-test (Table 4) were used to analyze the research data.

As shown in Table 3, the Mean±SD scores for learning outcomes in experimental group 1 were 9.43±3.79 in the pre-test and 14.14±0.78 in the post-test. In experimental group 2, the Mean±SD scores for learning outcomes were 9.85±3.01 in the pre-test and 13.65±3.11 in the post-test. In the control group, the Mean±SD

Table 2: Demographic characteristics of the participants

Variables	Grouping	Control		Gamification with uncertainty in rewards		Gamification with fixed rewards	
		Mean±SD	No.	Mean±SD	No.	Mean±SD	No.
Age	12-13	12.14±0.35	21	12.12±0.34	32	12.12±0.33	31
Gender	Male	---	21	---	32	---	31
	Female	---	0	---	0	---	0

*SD: Standard Deviation

Table 3: Descriptive statistics

Dimensions		Group 1 Mean±SD	Group 2 Mean±SD	Control Mean±SD
Learning	Pre-test	9.43±3.79	9.85±3.01	8.47±3.05
	Post-test	14.14±3.52	13.65±3.11	10.85±4.04

*SD: Standard Deviation

Table 4: Paired samples t-test

Groups	Mean±SD	t	P-value
Group 1(pre-test/post-test)	-4.70±2.40	-11.043	0.001
Group 2 (pre-test/post-test)	-3.79±2.54	-8.310	0.001
Control (pre-test/post-test)	-2.38±3.30	-3.301	0.004

*SD: Standard Deviation

Table 5: Analysis of covariance of learning

Dimensions		Group 1 Mean±SD	Group 2 Mean±SD	Control Mean±SD	F	P-value
Learning	• Pre-test	9.43±3.79	9.85±3.01	8.47±3.05	6.436	0.003
	• Post-test	14.14±3.52	13.65±3.11	10.85±4.04		
(I) group	**(J) group**		**Mean Difference (I-J)**			**P-value**
Control	• Certain		-1.794*			0.017
	• Uncertain		-2.585*			0.001
Certain	• Control		1.794*			0.017
	• Uncertain		-0.791			0.225
Uncertain	• Control		2.585*			0.001
	• Certain		0.791			0.225

*SD: Standard Deviation

scores for learning outcomes were 8.47±3.05 in the pre-test and 10.85±4.04 in the post-test.

In response to research questions 1 and 2, examining the impact of gamification with uncertainty in rewards and fixed rewards on students' learning, paired samples t-tests were employed (Table 4). The results revealed significant impacts of gamification on the learning outcomes for both experimental groups. Specifically, Group 1, characterized by uncertainty in rewards, exhibited a mean difference of -4.70 with a standard deviation of 2.40 and a standard error mean of 0.425. Similarly, Group 2, utilizing fixed rewards, displayed a mean difference of -3.79, with a standard deviation of 2.54 and a standard error mean of 0.457. In contrast, the control group demonstrated a mean difference of -2.38, a standard deviation of 3.30, and a standard error mean of 0.721. These findings suggest that both experimental groups outperformed the control group regarding learning outcomes.

To address research question 3 regarding the disparity in learning outcomes when employing gamification with uncertain rewards, gamification with fixed rewards, and conventional methods, an analysis of covariance (ANCOVA) was utilized. The results from the univariate tests, which explore the effect of group on post-learning outcomes, indicate a significant difference between groups ($F=6.43$, $P=0.003$) after controlling for pre-test effects (Table 5). This significant difference suggests that the employed gamification-based e-learning method has a notable impact on sixth-grade students' science learning, with a 95% confidence level.

Furthermore, post-hoc analysis using pairwise comparisons and the Least Significant Difference (LSD) test revealed a significant discrepancy in learning test scores between the experimental groups and the control group ($P<0.05$), providing additional evidence for the effectiveness of the gamification-based e-learning approach. Interestingly, while the mean score of the group with uncertain rewards was higher, no significant difference was observed between the two experimental groups, implying that the gamification-based e-learning method was equally effective for both groups.

Discussion

The finding of this study shows that e-learning methods based on gamification significantly impact the learning of sixth-grade students in science courses. This finding is supported by previous research carried out by Mohammadhasseini and Aghazadeh (8), Legaki and colleagues (5), and several other studies (7, 9, 11, 12). Mohammadhasseini and Aghazadeh's study compared the effects of three instructional approaches of multimedia, digital gamification, and face-to-face educational games on English vocabulary learning. The research followed a pretest-posttest experimental design indicating a significant difference among the multimedia, gamification, and face-to-face educational game groups. Both the gamification group

and the face-to-face educational game group demonstrated superior learning outcomes (8).

Similarly, Legaki and colleagues investigated the effects of challenge-based gamification on learning in statistics education. The study found that challenge-based gamification positively influenced learning outcomes compared to traditional teaching methods, particularly among female students and those enrolled in the School of Electrical and Computer Engineering (5).

Gamification also includes elements that can enhance student learning, such as competition. Competing against themselves or a group of peers motivates learners to succeed (26). The learning effects of competition are shaped by social interaction and learners' eagerness to see their names at the top of the list or their scores compared to their peers. Extrinsic motivational rewards achieved through targeted competition goals are effective tools until intrinsic motivation can develop. The ranking provides the criteria that make the competition an effective pedagogical tool as students begin to increase their self-efficacy. Students learn the speed of learning, comparative analysis, and motivation to gain experience to delve deeper into a topic (27).

This study used fixed and variable scoring along with chance. The researcher observed that students in both experimental groups were motivated to score the most points in the competition. This motivation led them to delve deeper into educational topics and engage more intensively. Furthermore, no significant difference was found between the two test groups, which contradicts the research of Howard Jonzo and Demetriou (24). Including a fixed and variable gamification element might be responsible for the lack of difference, as it enhances students' motivation to learn. The difference in how points are awarded should be more manifest in the game to be effective. This is in addition to the overall effects of gamification on learning and should significantly impact student learning.

Dehqanzadeh and colleagues (10) demonstrated that the gamification-based electronic environment has a more significant impact compared to the electronic environment without gamification. Consequently, it is recommended that gamification be incorporated into higher education settings to enhance learning outcomes and student engagement. Furthermore, these findings are consistent with previous research studies (11, 12).

Gamification is a pedagogical approach that uses game elements to engage learners in educational environments (22). Game-based learning can promote active engagement in learning and play a critical role in developing cognitive and emotional knowledge. In games with a learning aspect, players must follow a set of rules to achieve specific learning objectives. Such games provide an engaging and enjoyable learning experience by providing a context for simulation and active learning (7).

The effectiveness of game-based learning is due to the use of gamification elements such as rewards, rating tables, scoring, challenges, and feedback, which enhance learning and learner engagement (22). For instance, in the gamification environment, challenges are designed to set tasks for learners, and they receive rewards for solving them. Learners receive rewards and points for each correct answer or solving a learning challenge, which increases their motivation and engagement in the gamification environment. Learners receive feedback through rewards, points, or text when their answer or activity is correct in the gamification environment. These elements create an immersive and engaging learning experience for learners. Gamification takes advantage of the motivational properties of games to improve learner engagement, progress, and sustainability.

In its most effective state, gamification can facilitate the "flow state" in learners, which leads to greater engagement and learning. According to Arnold (3), gamified environments create value through voluntary participation and high engagement, making learning enjoyable for learners. In this setting, students require more time to complete each step as they progress from fundamental levels

to mastery. Gamification can stimulate this motivating behavior in learners and deepen their engagement. The gamified environment gives learners the opportunity and motivation to engage more with the learning material. If they fail, they can keep trying until they succeed — a feature not typically found in traditional training. Game-based learning is enjoyable for learners, and when they discern learning as fun, their engagement is heightened, resulting in increased learning. Arnold also found that learners are more engaged in learning through game-based activities and are rewarded with knowledge and skills in a game-based environment (3).

Given the importance of the research topic and its findings, teachers and instructors should use gamification elements in their classrooms, especially in e-learning, to increase academic engagement and learning. Future research should examine and compare other gamification scoring and reward elements, such as badges, leaderboards, and loot boxes. Based on the findings of this research, future studies should look into awarding points based on higher levels of chance and incorporating more randomness and chance into gameplay. Researchers should also examine the effects of increasing this independent variable.

Limitations and Suggestions

This study is subject to certain limitations that warrant careful consideration and attention. Firstly, the sample size was relatively small, consisting of only the sixth-grade students from a single city in 2021. Therefore, caution should be exercised when generalizing the findings to other populations and contexts. Secondly, convenience sampling may have introduced selection bias and limited the sample's representativeness. Finally, although the quasi-experimental design with a pre-test/post-test method and a control group is valid, a randomized controlled trial may have been a more robust design choice. These limitations highlight the need for further research with larger and more diverse samples to validate the effectiveness of gamification as a teaching approach and to explore its potential constraints and disadvantages in different settings.

Conclusion

In conclusion, the results of this study indicate that the implementation of gamification, regardless of the type of rewards (uncertain or fixed), positively influenced the learning of sixth-grade students. While there was no significant difference in learning outcomes between the two gamification groups, integrating gamification in e-learning practices could enhance student learning outcomes. These findings suggest that educators and e-learning designers should consider incorporating gamification strategies, including elements of uncertainty and chance, to promote student engagement and create more enriching learning experiences in elementary school settings.

Acknowledgments

There is nothing to declare.

Authors' Contribution

YM and NM were responsible for the research idea and its design. SG was responsible for executing the research and data collection. AG was responsible for drafting and editing the manuscript. All authors have read and approved the final version of the manuscript.

Conflict of Interest

None declared.

Ethical Considerations

In this research, participants were first briefed about the study's goals and were provided the consent to take part. They were free to leave the investigation at any point if they no longer wished to collaborate. Upon completion of the research, participants gained access to the training methods used by other groups. The data was kept confidential throughout the study, and the research assistant reviewed and supervised

its ethical aspects. This research project was approved by the Islamic Azad University, Science and Research Branch, Tehran, Iran, with an approval number of 34400, and it was reviewed for both ethical and scientific aspects.

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Availability of Data and Materials

The data supporting the findings of this study can be accessed by contacting the corresponding author, available upon reasonable request.

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