Evaluating the Effectiveness of Gamification Technology in Teaching Science Subjects

Anuarbek Amanov, Khoja Akhmet Yasawi International Kazakh-Turkish University, Kazakhstan
Nurseit Zhunissov, Khoja Akhmet Yasawi International Kazakh-Turkish University, Kazakhstan
Arypzhan Aben, Khoja Akhmet Yasawi International Kazakh-Turkish University, Kazakhstan

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Abstract

This study is designed to develop an educational platform based on gamification elements to increase the motivation and activity of 7th grade students in teaching natural sciences and to comprehensively evaluate its effectiveness. In the current education system, the decline in interest in natural sciences and the passivity of students are one of the pressing issues. In this regard, during the study, an interactive digital platform based on game mechanics (points, badges, leaderboards, levels, reward system) was developed, which ensures the active participation of students in the learning process. The developed platform was tested in an experimental group among 7th grade students. Within the framework of the research design, a comparative analysis was conducted with traditional teaching methods, and the level of students' academic achievements and interest in the subject was determined. Psychometric tools widely used at the international level were used for the assessment, in particular, the Learning Motivation and Learning Strategies Assessment Questionnaire (MSLQ) and the Intrinsic Motivation Inventory (IMI). In addition, preliminary and final testing methods were used to determine the learning outcomes. The results of the study showed that the use of a gamified platform significantly increased students' cognitive interest in natural sciences, learning activity, and academic performance. Among students, there was a development of self-learning, competitive, and cooperative skills. The proposed gamification approach can be considered an effective tool for revitalizing the educational process and improving the quality of teaching. The results of the study prove the importance of introducing innovative pedagogical technologies in the context of digitalization of education.

Keywords: gamification, science subjects, teaching technology, learning motivation, digital education, self-determination theory, academic achievement

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Introduction

The digital transformation in education today has transformed the educational environment by increasing access to interactive content, instant feedback, and improved learning analytics. It has transformed the educational landscape by expanding access to student-centered learning. However, the availability of technology alone does not guarantee active learning. A persistent challenge in secondary school science education (computer science, physics, chemistry) is that students may perceive scientific concepts as abstract, difficult, or disconnected from everyday experience. When instruction relies heavily on explaining and reproducing information, students may become passive, which can weaken interest, persistence, and academic engagement.

Gamification has emerged as one approach for addressing this problem. Deterding et al. (2011) define gamification as the use of game-design elements in non-game contexts. In education, this means retaining curricular goals while incorporating mechanisms such as points, levels, badges, challenges, progress indicators, leaderboards, and rewards. These mechanisms can make progress visible, provide frequent feedback, and create structured goals that encourage learners to continue participating. Importantly, gamification differs from game-based learning: the curriculum does not have to become a complete game; instead, selected game elements are layered onto instructional activities.

The evidence base is broadly encouraging but not uniformly positive. Hamari et al. (2014) concluded that gamification often produces beneficial outcomes, while emphasizing that effects depend strongly on context and users. In a meta-analysis, Sailer and Homner (2020) reported small positive effects on cognitive, motivational, and behavioral outcomes, with the strongest and most stable evidence for cognitive learning. Their analysis also showed that social interaction matters: combinations of competition and collaboration can outperform purely competitive designs. In science education specifically, Kalogiannakis et al. (2021) identified growing use of gamification and emphasized the importance of linking game mechanics to learning objectives rather than treating them as decorative add-ons. A more recent systematic review of primary and secondary education likewise found that research commonly addresses motivation, participation, self-regulation, and engagement, while calling for broader and more rigorous evaluation of school engagement (Ruiz et al., 2024).

This study is conducted with seventh grade students studying science subjects. The purpose of this study is to evaluate a game platform in a digital environment. The platform is designed around a simple motivational loop: students engage in curriculum tasks by playing Kazakh games. They progress through levels and are given opportunities for individual and collaborative achievement. The study compares changes in learning motivation and academic performance between a group using the platform and a control group receiving traditional instruction.

Accordingly, the study addressed three research questions: (1) How does a gamified digital platform affect seventh grade students' motivation and engagement in science? (2) How does the intervention affect academic achievement compared to traditional instruction? (3) What broad learning behaviors, such as self-management, competition, and collaboration, emerge during the gamified intervention?

Theoretical Background

Gamification as an Instructional Design Approach

In effective education, gamification is not just about adding rewards to existing tasks. Its value lies in the connection between game mechanics, learning objectives, feedback, and student behavior.

- Points can indicate task completion and effort;
- Badges can indicate mastery or persistence; levels can indicate increasing difficulty;
- Progress bars can support monitoring;
- Leaderboards can introduce social comparison.

When these elements are aligned with curriculum objectives, they can create a clear sense of progress and help students understand what they have done and what they need to learn.

Research also cautions against over-reliance on external reward systems. Leaderboards that repeatedly highlight the same high-performing students can be frustrating to others, and points awarded for superficial actions can distract from conceptual understanding. For these reasons, the platform in this study combined competitive mechanisms with team tasks and multiple forms of recognition. The design aims to make improvement, participation, and mastery visible, rather than just rewarding the highest absolute score.

Self-Determination Theory and Motivation

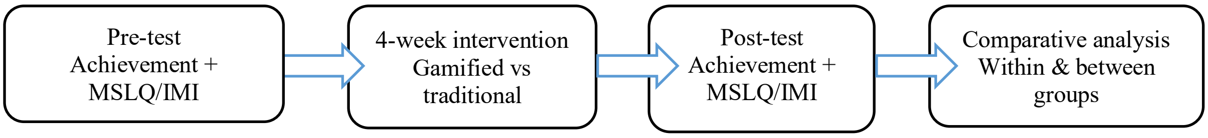
The motivational logic of the platform is consistent with self-determination theory (SDT). Ryan and Deci (2000) explain high-quality motivation through the satisfaction of three basic psychological needs: autonomy, competence, and relatedness. Autonomy concerns the experience of meaningful choice and self-direction; competence involves feeling capable of improving and succeeding; relatedness reflects connection with other people. Gamified learning can support competence through immediate feedback and visible progress, autonomy through choices among tasks or challenge levels, and relatedness through peer recognition and collaborative activities. Sailer et al. (2017) similarly demonstrated that different game-design elements can influence psychological need satisfaction in different ways. This theoretical perspective is useful because it shifts attention from whether students simply “like games” to whether the learning environment supports psychological conditions associated with sustained engagement.

Materials and Methods

Research Design and Participants

A quasi-experimental pretest/posttest control group design was used. Participants were seventh-grade students from a science (computer science, physics, chemistry) cohort. The experimental group received instruction via a gamified digital platform, while the control group continued traditional non-gamified instruction. Both groups received the same curriculum over the same period of time. The intervention lasted four weeks. The available conference dataset does not indicate the exact number of participants or group sizes; if required by the conference template, these values should be entered from the participant register before final submission.

Figure 1
Pre-test/Intervention/Post-test Research Design



Gamified Digital Platform

The platform incorporated game mechanics directly into science learning activities:

- students earned points for completing assignments, quizzes, and experiments, as well as engaging games;
- badges recognized milestones of mastery and sustained effort;
- levels indicated progression from basic to advanced topics;
- leaderboards made classroom progress visible;
- and rewards unlocked recognition or additional content.

The student dashboard displayed subject progress, recent badges, activity series, and class rankings. The platform therefore transformed otherwise abstract progress information into instant visual feedback that students could track as they engaged.

Table 1
Gamification Elements and Intended Educational Functions

Element	Implementation in the platform	Educational function
Points	Tasks, quizzes, and experiments	Immediate performance feedback and reinforcement
Badges	Mastery, effort, and milestones	Recognition of specific achievement and persistence
Levels	Progression from basic to advanced units	Visible progression and graduated challenge
Leaderboards	Class ranking by accumulated points	Social comparison and healthy competition
Rewards	Unlockable recognition/content	Short-term reinforcement linked to achievement
Collaborative challenges	Team-based science tasks	Peer support, relatedness, and cooperative problem solving

Measurement Instruments

Three forms of measurement were used. First, motivational orientations and learning strategies were assessed using components derived from the Motivated Strategies for Learning Questionnaire (MSLQ). The MSLQ was developed to assess motivation and learning strategies in course contexts and includes dimensions such as goal orientation, task value, self-efficacy, cognitive strategy use, metacognition, and effort regulation (Pintrich et al., 1991). Because the original instrument was designed for college students, any seventh-grade adaptation should be documented carefully, including translation procedures and reliability estimates.

Second, the Intrinsic Motivation Inventory (IMI) was used to capture students' subjective experience of learning activities, particularly interest/enjoyment, perceived competence, effort/importance, and pressure/tension. The IMI has been widely used to operationalize intrinsic motivation and related constructs; its psychometric properties have been examined in prior research (McAuley et al., 1989). In this study, MSLQ- and IMI-derived indicators were summarized into the motivation index reported in the presentation dataset.

Third, identical curriculum-aligned achievement tests were administered before and after the intervention. Using the same assessment framework for both groups enabled direct descriptive comparison of change over time. The combination of achievement measures and motivational instruments allowed the intervention to be evaluated across both cognitive and affective learning outcomes.

Procedure

The study consisted of four phases. In the initial phase, both groups completed pre-achievement testing and motivation measures. Over the next four weeks, the experimental group was taught the same curriculum using a gaming platform, while the control group was taught traditional teaching. At the end of the intervention, both groups completed the testing structure and motivation measures at the same level. Finally, changes before and after integration were compared within and between groups. Qualitative classroom observations were also used to identify changes in self-management, competitive behavior, and cooperation.

Statistical Analysis

This conference dataset contains group-level pretest and posttest means, but does not include participant-level scores, sample sizes, standard deviations, or standard errors. Therefore, the analysis presented here is descriptive, not inferential. Our absolute advantage was calculated as a pretest minus a posttest. The descriptive benefit difference was calculated by subtracting the benefit of the control group from the benefit of the experimental group. The relative percent change from baseline was also calculated as (posttest − pretest)/pretest × 100. These calculations do not indicate statistical significance but describe the magnitude of the observed change.

For the final empirical manuscript, participant-level data should be analyzed with methods appropriate to a pre-test/post-test comparison. An independent-samples t-test on change scores can be used when its assumptions are satisfied, but ANCOVA is generally preferable because it compares post-test outcomes while adjusting for baseline differences. Standardized effect sizes such as Cohen's d (with pooled standard deviation) and 95% confidence intervals should accompany p-values. If questionnaire subscales are reported, internal consistency (for example, Cronbach's alpha or omega) should also be provided. These quantities cannot be validly reconstructed from group means alone and were therefore not fabricated in this paper.

Results

The descriptive data show a consistently larger improvement in the experimental group. For the composite motivation index, the experimental group increased from 58 at pre-test to 84 at post-test, an absolute gain of 26 points. The control group increased from 56 to 63, a gain of 7 points. Thus, the experimental group's descriptive motivation gain exceeded the control group's gain by 19 points. Relative to baseline, the motivation index increased by 44.8% in the experimental group compared with 12.5% in the control group.

Academic achievement followed the same pattern. The experimental group increased from 61 to 88, a gain of 27 points, whereas the control group increased from 60 to 69, a gain of 9 points. The difference-in-gains was therefore 18 points. Relative to baseline, academic achievement increased by 44.3% in the experimental group compared with 15.0% in the control group. Baseline group means were close for both outcomes, whereas the post-test separation was much larger after the four-week intervention.

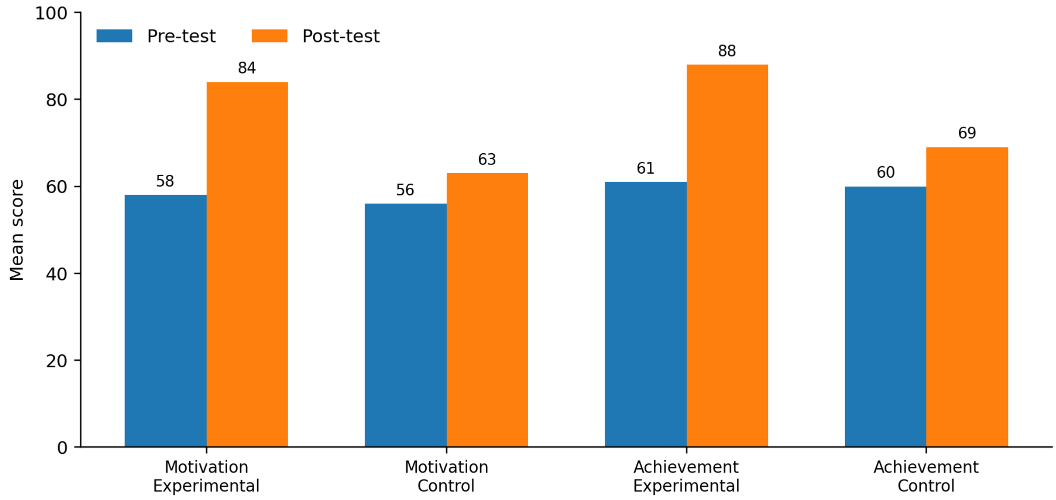
Table 2

Descriptive Changes in Motivation and Academic Achievement

Outcome	Group	Pre	Post	Gain	Relative change
Motivation	Experimental	58	84	+26	+44.8%
Motivation	Control	56	63	+7	+12.5%
Achievement	Experimental	61	88	+27	+44.3%
Achievement	Control	60	69	+9	+15.0%

Figure 2

Pre-test and Post-test Mean Scores by Group and Outcome



Beyond the numerical scores, classroom observations in the experimental group indicated three notable behavioral shifts. First, students showed greater self-directed learning by taking more initiative in pacing and approaching tasks. Second, the leaderboard and progress mechanisms promoted healthy competition focused on improvement and visible progress. Third, team-based challenges supported peer assistance and cooperative problem solving. These qualitative observations are consistent with the platform's design, which combined individual progression with social interaction.

Discussion

The purpose of this study was to evaluate whether a gamified digital platform could strengthen motivation and achievement in seventh-grade natural science. The descriptive pattern is clear: both groups improved over four weeks, but the gains in the experimental group were substantially larger for both motivation and academic performance. The fact that the control group also improved is expected because it continued to receive science instruction. The more informative comparison is the difference in the size of the gains, which favored the experimental group by 19 points for motivation and 18 points for achievement.

This pattern is compatible with the broader research literature. Sailer and Homner (2020) found positive average effects of gamification on cognitive, motivational, and behavioral learning outcomes, although the motivational and behavioral effects were less stable in high-rigor subsets. This caution is important for interpreting the present results. The four-week study suggests a promising effect, but the current conference dataset does not provide the participant-level information needed to establish whether the observed differences are statistically reliable or to quantify standardized effect sizes. Accordingly, the findings should be described as substantial descriptive improvements rather than as confirmed statistically significant effects.

The results are also plausible from an SDT perspective. Points, levels, badges, and progress indicators may strengthen perceived competence by making improvement visible. Allowing students to monitor progress and engage with structured challenges may support autonomy. Leaderboards and team challenges create a social dimension that can support relatedness when competition is balanced with cooperation. This balance matters because meta-analytic evidence suggests that competitive-collaborative designs can be more effective than competition alone for motivational and behavioral outcomes (Sailer & Homner, 2020).

For science education, the platform has additional pedagogical relevance. Scientific learning often involves sequential conceptual development, problem solving, testing ideas, and receiving feedback. These characteristics map naturally onto levels, challenges, quests, and progress systems. A well-designed platform can therefore make the logic of scientific progression visible rather than merely adding entertainment. The systematic review by Kalogiannakis et al. (2021) similarly emphasizes the potential of gamification in science education while noting the need for careful design and evaluation.

The observed development of self-directed and cooperative behaviors also extends the interpretation beyond test scores. Recent research on school engagement emphasizes that engagement includes behavioral, emotional, cognitive, and self-regulatory components rather than motivation alone (Ruiz et al., 2024). From this perspective, a useful gamification system should not simply maximize point collection. It should help students set goals, monitor progress, persist with challenging tasks, collaborate productively, and connect feedback to learning decisions.

Several limitations should be acknowledged. The intervention was relatively short, so a novelty effect cannot be excluded. The available dataset does not provide sample size, dispersion measures, or participant-level scores, preventing valid t-tests, ANCOVA, confidence intervals, and Cohen's d calculations. In addition, the MSLQ was originally designed for older learners; the specific seventh-grade adaptation and its psychometric reliability should be reported in a full journal version. Future work should therefore use a larger documented sample, report validated scale properties, extend the intervention period, analyze retention, and investigate whether effects differ according to initial achievement, gender, or learner profile.

Conclusion

The study demonstrates the practical potential of a gamification-based digital platform for seventh-grade science education. Over a four-week period, the experimental group showed much larger descriptive improvements than the control group in both the motivation index and academic achievement. Motivation increased by 26 points in the experimental group compared with 7 points in the control group, while achievement increased by 27 points compared with 9 points. The resulting difference-in-gains favored the gamified condition by 19 points for motivation and 18 points for achievement.

These findings suggest that gamification can be most useful when game mechanics are tightly connected to curriculum objectives and when individual progress is combined with cooperative learning. Points, badges, levels, progress tracking, leaderboards, and rewards should function as feedback and self-regulation supports rather than as isolated incentives. The platform's observed influence on self-directed learning, healthy competition, and cooperation further indicates that gamification can contribute to a more active, learner-centered science classroom. A larger study with participant-level statistical analysis is the next step for establishing inferential evidence and standardized effect sizes.

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Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

Generative artificial intelligence technologies were used only for the translation and grammar checking of this manuscript. In particular, ChatGPT (OpenAI), Claude.ai tools were used to improve the translation and grammar of the text into English, and the readability of the text. B This artificial intelligence tool was not used to generate research ideas, methodology, data analysis, results, or conclusions.

References

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining "gamification." In *Proceedings of the 15th International Academic MindTrek Conference* (pp. 9–15). ACM. https://doi.org/10.1145/2181037.2181040

Hamari, J., Koivisto, J., & Sarsa, H. (2014). Does gamification work? A literature review of empirical studies on gamification. In *2014 47th Hawaii International Conference on System Sciences* (pp. 3025–3034). IEEE. https://doi.org/10.1109/HICSS.2014.377

Kalogiannakis, M., Papadakis, S., & Zourmpakis, A.-I. (2021). Gamification in science education: A systematic review of the literature. *Education Sciences, 11*(1), 22. https://doi.org/10.3390/educsci11010022

McAuley, E., Duncan, T., & Tammen, V. V. (1989). Psychometric properties of the Intrinsic Motivation Inventory in a competitive sport setting: A confirmatory factor analysis. *Research Quarterly for Exercise and Sport, 60*(1), 48–58. https://doi.org/10.1080/02701367.1989.10607413

Pintrich, P. R., Smith, D. A. F., García, T., & McKeachie, W. J. (1991). *A manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ)*. National Center for Research to Improve Postsecondary Teaching and Learning, University of Michigan.

Ruiz, J. J. R., Sanchez, A. D. V., & Figueredo, O. R. B. (2024). Impact of gamification on school engagement: A systematic review. *Frontiers in Education, 9*, 1466926. https://doi.org/10.3389/feduc.2024.1466926

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68–78. https://doi.org/10.1037/0003-066X.55.1.68

Sailer, M., Hense, J. U., Mayr, S. K., & Mandl, H. (2017). How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction. *Computers in Human Behavior, 69*, 371–380. https://doi.org/10.1016/j.chb.2016.12.033

Sailer, M., & Homner, L. (2020). The gamification of learning: A meta-analysis. *Educational Psychology Review, 32*(1), 77–112. https://doi.org/10.1007/s10648-019-09498-w

Contact email: anuarbek.amanov@ayu.edu.kz