Eğitimde Teknoloji Uygulamaları Dergisi
Journal of Technology Applications in Education 2025, Vol. 6 (1), 11-22
https://doi.org/10.29329/jtae.2025.1403.2

Original article

Development and Evaluation of an Educational Digital Game for Elementary School Students

Hasan Hüseyin Çelik [a], Elif Sude Alarçin [a], Furkan Tuna [a],
Ebru Yılmaz İnce [a, *] & Murat İnce [a]

[a] Department of Computer Technologies, Isparta University of Applied Sciences, Isparta, Türkiye

Abstract

This study aimed to enhance the motivation and learning processes of elementary school students in mathematics and English through a gamified educational approach. An educational digital game was developed based on popular multiplayer game mechanics while integrating curriculum-aligned learning tasks. The game was tested with 19 second-grade students at Isparta Şehit Mehmet Ünal Primary School. Post-game surveys indicated that most students found the game enjoyable, educational, and supportive of collaborative skills. Specifically, students reported enjoying the game. Some students noted certain tasks were challenging, highlighting the need for differentiated content. Overall, results suggest that the game effectively supports targeted learning outcomes and can enhance student motivation. Future studies should explore long-term effects and adaptation to different grade levels and subjects.

Keywords: Educational Game, Elementary Students, Gamification, Learning Motivation, Game Based Learning

Received: 17 October 2025 * **Accepted:** 30 December 2025 * **DOI:** https://doi.org/10.29329/jtae.2025.1403.2

* **Corresponding author:**

Yılmaz İnce E. is an Assoc Prof., in Department of Computer Sciences, Isparta University of Applied Science, Isparta, Türkiye. Her research interests include gigital games, metaverse anf sofware. She has lived, worked, and studied in Isparta, Türkiye.
Email: ebruince@isparta.edu.tr

INTRODUCTION

Game-based learning and gamification have gained increasing attention as effective approaches to foster student motivation, engagement, and academic achievement in elementary education. These approaches transform traditional classroom learning into interactive experiences by incorporating game elements such as points, levels, and challenges. According to Sappaile (2024), the integration of points, rewards, and level progression significantly improved motivation among elementary school students, indicating that gamification can directly influence learners' willingness to participate in academic activities. Similarly, Guro and Corpuz (2025) reported that gamification strategies—including badges, leaderboards, and point-based systems—led to measurable improvements in mathematics performance, highlighting the potential of digital games to enhance cognitive outcomes.

Experimental studies further emphasize the cognitive and emotional benefits of gamification. In a randomized controlled trial, Coelho et al. (2025) demonstrated that the combination of multiple game elements yielded the strongest positive effects on learning and motivation, while relying solely on badges increased cognitive load. These findings suggest that the design of gamified systems requires a balance between challenge and cognitive demand. In addition, systematic reviews reinforce these individual results. For example, a large-scale review of 90 studies published between 2013 and 2023 concluded that gamification enhances school engagement across several dimensions, including motivation, behavioral participation, and socio-emotional connectedness (Ruiz et al, 2024). Likewise, in the field of language learning, gamification has been shown to strengthen working memory, attention control, and retention, although sustained engagement requires innovative and adaptive instructional design (Al-Khresheh, 2025).

Digital game-based learning at the elementary school level has become a rapidly expanding field of research in recent years, particularly due to its potential to enhance student engagement, improve learning outcomes, and strengthen classroom interaction in mathematics and STEM education. For instance, a systematic review focusing on elementary mathematics education examined 45 studies published between 2006 and 2023 using a PRISMA flow and identified the most frequently addressed subject areas, research designs, and game types. The review also highlighted that effectiveness outcomes vary depending on game design characteristics, duration of implementation, and assessment instruments, thereby pointing to critical gaps in the literature (Gui et al., 2023; Dan et al., 2024). Similarly, a meta-analysis conducted in the context of elementary STEM education synthesized findings from 18 studies and reported that DGBL interventions generally yield positive effects on academic achievement; however, variables such as game genre, platform, and intervention length were found to significantly moderate these effects (Behnamnia et al., 2024). Another crucial dimension that strengthens the impact of digital games is design quality. A comprehensive framework proposed for serious educational games for children integrates instructional objectives and learning context with key

design principles—such as narrative, game mechanics, interaction, feedback and support systems, accessibility, and children's preferences—thus providing researchers and designers with a practical foundation for both development and evaluation processes (Asadzadeh et al., 2024). Empirical classroom implementations reflect a similar trend: in a quasi-experimental pretest–posttest control group study conducted with second-grade students in Türkiye, the integration of digital game-based applications such as Wordwall, GeoGebra, and Derslig into mathematics instruction produced findings indicating the maintenance or improvement of students' attitudes toward mathematics. The results further emphasize that the educational value of digital games emerges most strongly when they are embedded within a well-structured instructional design rather than being used in isolation (Dursun & Ulum, 2024).

Building on these foundations, the present study aims to design, develop, and evaluate a multiplayer educational digital game tailored for second-grade elementary school students. The game integrates curriculum-aligned tasks in mathematics and English while embedding collaborative multiplayer mechanics inspired by popular digital games. The primary objective is to examine the effects of this game on student motivation and learning outcomes in an authentic classroom environment.

MATERIALS and METHODS

Participants

The study was conducted with 19 second-grade students from Şehit Mehmet Ünal Primary School in Isparta, Türkiye. Participants were selected on a voluntary basis, and both parental consent and school administration approval were obtained prior to data collection. The sample consisted of 10 male and 9 female students, aged between 7 and 8 years. Students participated during regular class hours as part of the school's extracurricular activities.

Game Development

The educational digital game was developed using the Unity game engine and Photon Unity Networking 2 (PUN2) for multiplayer functionality. The design was inspired by popular multiplayer game mechanics while adapted to the cognitive and academic level of elementary school students.

The game included two primary components mathematics and English tasks. Mathematics tasks are number rounding, grouping numbers into ones and thousands, and solving simple arithmetic problems. English tasks are vocabulary matching, basic sentence building, and word recognition.

Tasks were embedded within a collaborative multiplayer environment. Players could navigate through different areas of the game world, interact with in-game objects, and complete tasks either individually or cooperatively. Visual design elements such as color-coded interactive objects were used to guide students' attention.

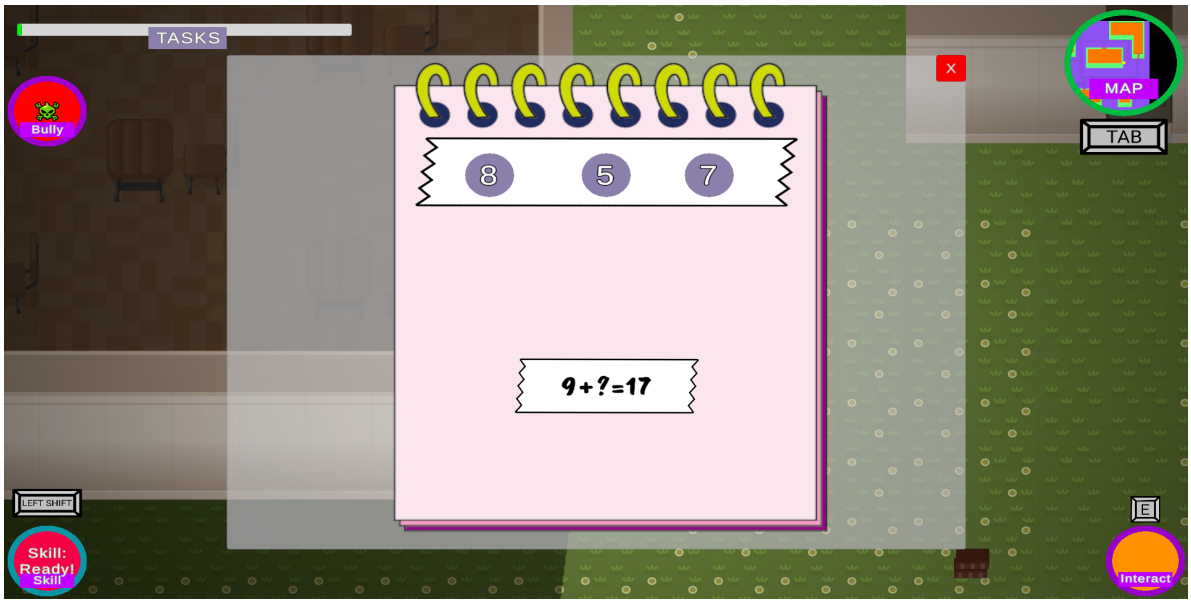

Figure 1. Example of the in-game environment and task interface.

Procedure

Before gameplay, students were given a brief orientation session to familiarize them with the controls and objectives of the game. Gameplay sessions lasted approximately 30 minutes and were conducted in a computer laboratory setting, with students divided into multiplayer groups of 4–5 players.

After completing the gameplay session, students filled out a structured survey designed by the research team. The survey included items on enjoyment, perceived learning, collaboration, and usability of the game. Responses were collected anonymously to encourage honest feedback.

Data Collection and Analysis

Data were collected through post-intervention questionnaires comprising both Likert-type items and open-ended questions, a common approach in educational game research to capture complementary quantitative and qualitative evidence of learner experiences. Quantitative data obtained from the Likert-scale items were analyzed using descriptive statistics (e.g., means, standard deviations, and frequency distributions) to identify overall trends and patterns in students' perceptions of the digital game and its educational value (Field, 2018; Plass et al., 2015). Responses to the open-ended questions were analyzed using thematic analysis, following a systematic process of familiarization, coding, theme development, and refinement, in order to generate in-depth insights into students' learning experiences and their suggestions for improvement (Braun & Clarke, 2006, 2021). The integration of quantitative and qualitative analyses enabled a more comprehensive interpretation of the findings by triangulating numerical trends with students' articulated views, thereby strengthening the validity of the results in line with mixed-methods research principles (Creswell & Plano Clark, 2018).

RESULTS

The development of the multiplayer educational game was guided by principles of flow, collaboration, and experiential learning. The purpose was to ensure that children not only engage with the mechanics of the game but also encounter meaningful educational tasks aligned with mathematics and English curricula. The following section illustrates the sequential flow of the gameplay experience, followed by survey-based evaluation data. Screenshots (Figures 2–8) provide step-by-step evidence of how players progress through the environment.

When the game begins, one player creates a lobby where the session is hosted (Figure 2). Other participants can browse available lobbies and join a selected room (Figure 3).

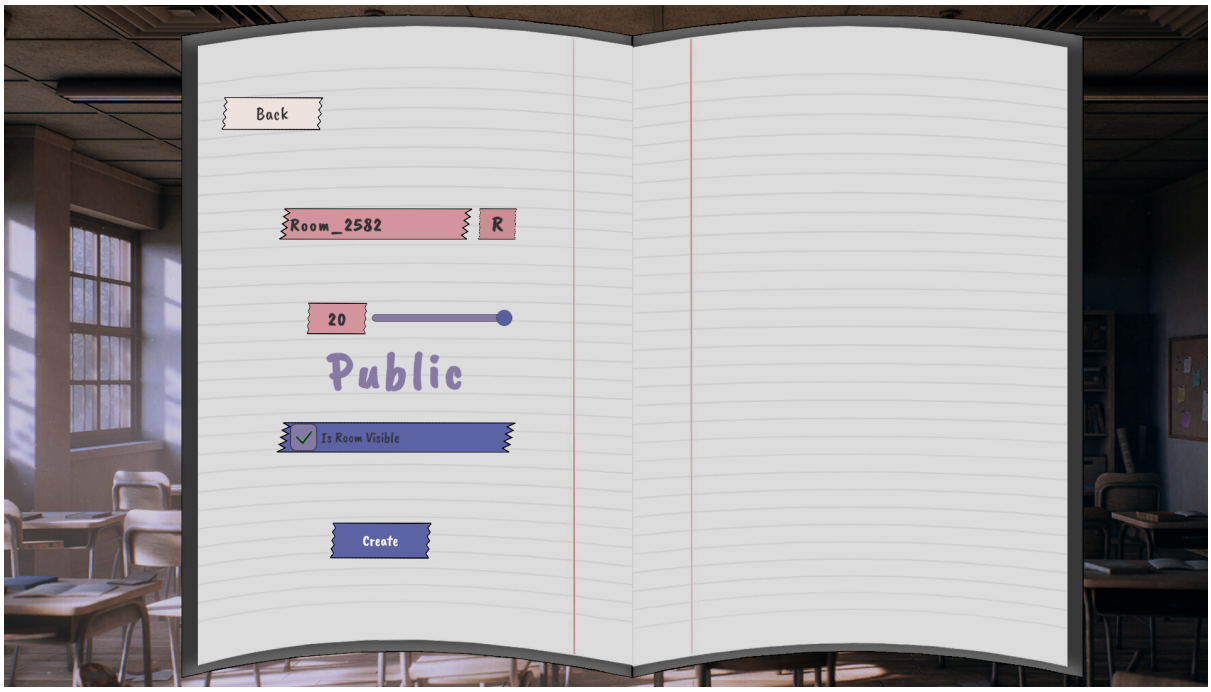

Figure 2. Lobby creation screen

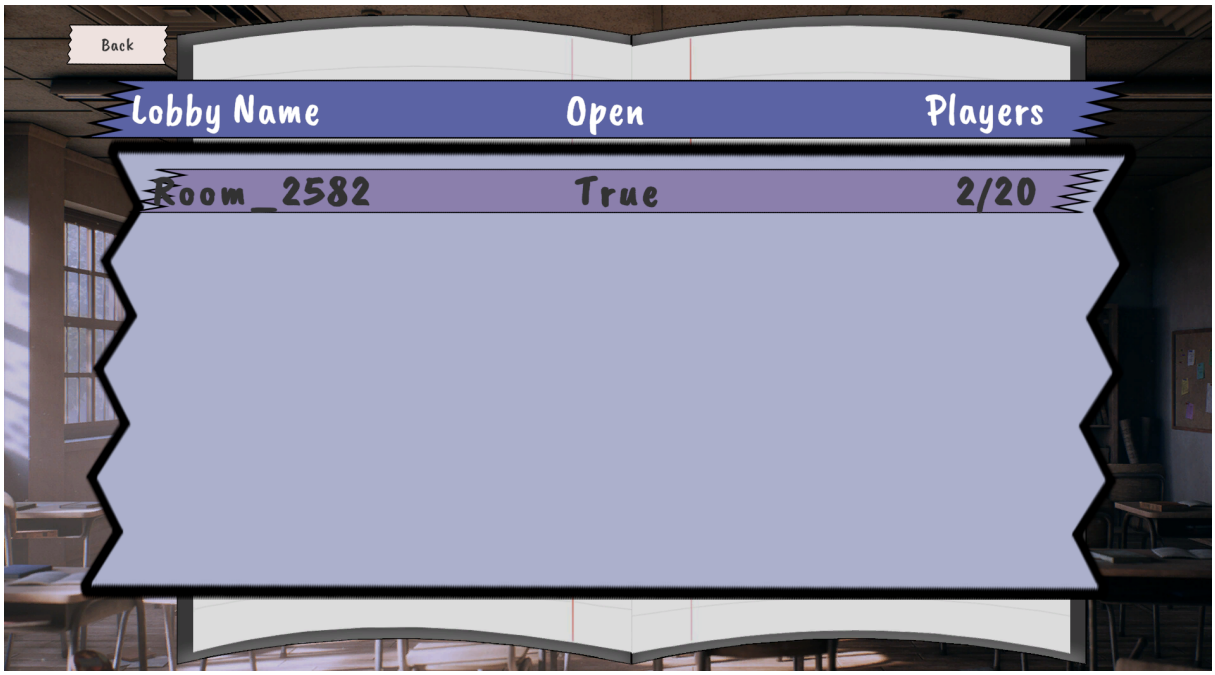

Figure 3. Lobby search and joining screen

Inside the lobby, players personalize their appearance by selecting avatar colors and cosmetic options. Each participant must confirm readiness by clicking the “Ready” button. Once all players are ready and at least five have joined, the “Start” button becomes active for the host player (master client), enabling the match to begin (Figure 4).

Figure 4. Lobby with cosmetic selections and activated start button

At the beginning of the session, the system automatically assigns roles to players: Student or Bully. Each player receives a dedicated role screen explaining their objective. Students aim to complete tasks, the Bully attempts to prevent their success by eliminating them, and eliminated Students transform into Ghosts (Figures 5, 6).

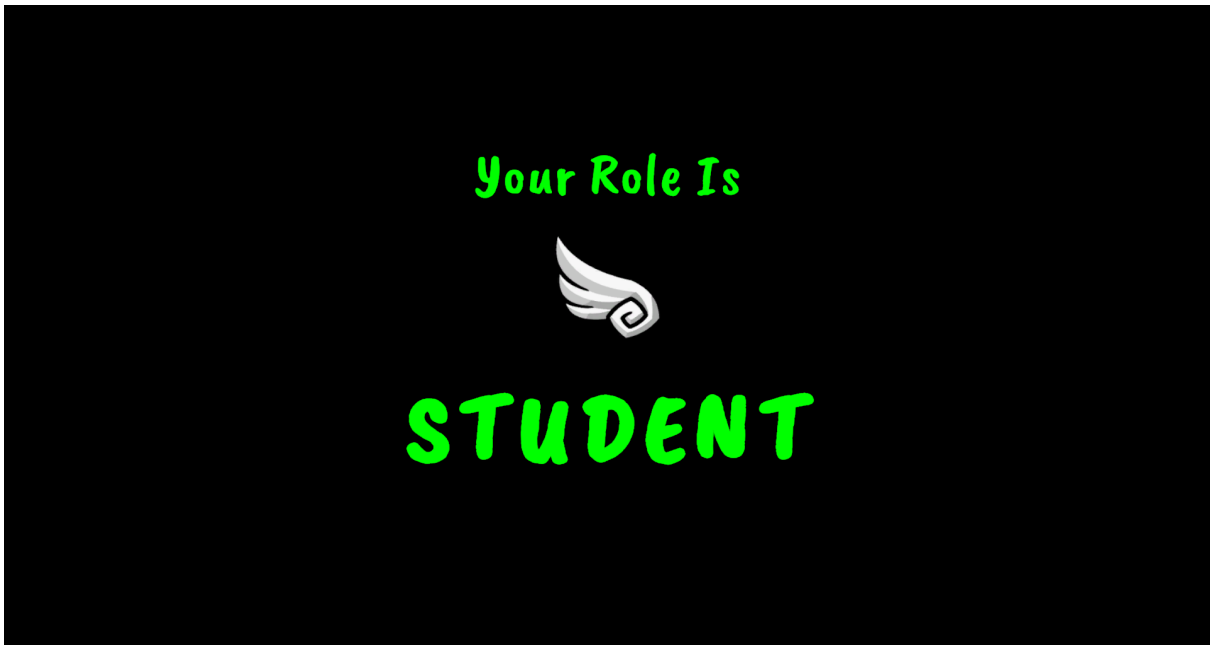

Figure 5. Student role screen

Figure 6. Bully role screen

Once inside the game map, Students begin performing subject-related mini-games such as mathematics and English exercises (Figure 7). Completion of all tasks leads to a collective victory for the Students. Alternatively, Students may call a meeting and vote out the Bully if identified correctly.

In Figure 7, the books visible in the environment function as task-opening objects that can be interacted with using the interact button located at the bottom right of the screen when approached closely. Among these, the books assigned as active tasks to the player glow in green, while others, although still task-opening objects, do not glow because they are not part of the randomly assigned tasks for that player in the ongoing game. Both glowing (assigned) and non-glowing (non-assigned) task objects are shown together in Figure 7. Additionally, the task bar displayed at the top left of Figure 7 indicates the ratio of tasks completed by all players in the room to the total required tasks for achieving victory.

Figure 7. Map with educational tasks in progress

The Bully, on the other hand, wins if all Students are eliminated before the tasks are completed. Eliminated Students continue playing as Ghosts: although invisible to others and unable to interact directly, Ghosts can still complete educational tasks to support the Student team (Figure 8).

Figure 8. Ghost character navigating the map

Finally, the outcome depends on whether the Students manage to finish all assigned tasks or correctly eliminate the Bully, or whether the Bully successfully disrupts them before task completion. This gameplay dynamic encourages collaboration, critical thinking, and persistence.

Survey results gathered after gameplay further reinforced the educational value of the experience. A total of 19 second-grade students participated in the study. Survey results gathered after gameplay provided quantitative insights into the students' experiences. The data, analyzed using descriptive statistics (mean and standard deviation) on a 5-point Likert scale, revealed strongly positive perceptions across key dimensions of enjoyment, perceived learning, and collaboration, while also highlighting specific areas for improvement.

The results for enjoyment were exceptionally high. The items "I would like to play the game again" (M=4.70, SD=0.651) and "Mini-games and tasks were fun" (M=4.65, SD=0.675) both yielded mean scores approaching the maximum, accompanied by low standard deviations. This indicates not only a very high level of enjoyment but also a strong consensus among participants, confirming the game's success in achieving its motivational objectives.

Regarding perceived learning, the data presents a nuanced picture. The statement "I both learned and had fun while playing" received a very high mean score (M=4.68, SD=0.582), demonstrating that students overwhelmingly felt the game successfully merged education with entertainment (see Table 1). However, the item "The game helped me remember class knowledge" had a lower mean (M=4.15) and a notably higher standard deviation (SD=0.930). This suggests that while the game was perceived as a fun learning tool overall, its direct effectiveness in reinforcing specific curricular knowledge was

experienced more variably by the students. This variability aligns with the qualitative feedback that some tasks were challenging and underscores the potential need for differentiated task design to accommodate diverse skill levels.

Finally, the collaboration aspect was also viewed positively. The item "It was easy to act as a team in the game" received a solid mean score (M=4.25). However, the standard deviation (SD=0.857) was higher than that for the enjoyment items, indicating less uniformity in the students' experiences with the collaborative mechanics. This suggests that while the multiplayer design was largely successful, the teamwork dynamics may not have been equally intuitive or accessible for all participants.

In conclusion, the descriptive statistics robustly support the game's efficacy in creating an engaging and motivating learning environment. The high means confirm positive reception, while the analysis of standard deviations provides critical depth, revealing where student experiences were uniform and where they diverged, thus offering valuable guidance for future iterations of the game.

Table 1. Survey responses about player experience

Item	Mean (M)	Standart Deviation (SD)
Enjoyment (I would like to play the game again)	4.70	0.651
Enjoyment (Mini-games and tasks were fun)	4.65	0.675
Perceived learning (The game helped me remember class knowledge)	4.15	0.930
Perceived learning (I both learned and had fun while playing)	4.68	0.582
Collaboration (It was easy to act as a team in the game)	4.25	0.857

Overall, the findings suggest that the multiplayer design successfully combined entertainment with educational objectives, fostering both motivation and knowledge acquisition in young learners.

Conclusion

This study demonstrated that a multiplayer digital game designed for second-grade students can effectively combine entertainment with curriculum-based educational content. By embedding mathematics and English tasks into a collaborative gameplay environment, the project supported both cognitive and social outcomes. Survey results showed that the majority of students reported high enjoyment and perceived learning benefits, suggesting that digital game-based learning can be a motivating and impactful tool in early education. However, some students found certain tasks challenging, indicating the need for differentiated task design to accommodate varying skill levels. Future research could include larger samples, long-term assessment of learning outcomes, and adaptation of the model for different grade levels or subject areas.

Ethics Approval

In all processes of this study, the principles of Pen Academic Publishing Research Ethics Policy were followed.

The study received ethical approval from the Ethics Committee of Isparta University of Applied Sciences on May 12, 2025 (Approval No: 2024/08).

REFERENCES

Al-Khresheh, M. H. (2025). The Cognitive and Motivational Benefits of Gamification in English Language Learning: A Systematic Review. *The Open Psychology Journal, 18*(1).

Asadzadeh, A., Shahrokhi, H., Shalchi, B., Khamnian, Z., & Rezaei-Hachesu, P. (2024). *Serious educational games for children: A comprehensive framework*. Heliyon, 10(6), e28108. https://doi.org/10.1016/j.heliyon.2024.e28108.

Behnamnia, N., Kamsin, A., & Hayati, S. (2024). Impact of digital game-based learning on STEM education in primary schools: A meta-analysis of learning approaches. Innoeduca. *International Journal of Technology and Educational Innovation, 10*(2), 113–140. https://doi.org/10.24310/ijtei.102.2024.19694

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Braun, V., & Clarke, V. (2021). *Thematic analysis: A practical guide*. SAGE.

Coelho, R. A., Ferreira, R., Costa, R., & Fernandes, C. (2025). The impact of educational gamification on cognition, emotions, and motivation: A randomized controlled trial. *Discover Education, 4*(1), 3. https://doi.org/10.1007/s40692-025-00366-x.

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). SAGE.

Dan, N. N., Trung, L. T. B. T., Nga, N. T., & Dũng, T. M. (2024). Digital game-based learning in mathematics education at primary school level: A systematic literature review. *Eurasia Journal of Mathematics, Science and Technology Education, 20*(4), em2423. https://doi.org/10.29333/ejmste/14377

Dursun, Z. B., & Ulum, H. (2024). The effect of educational digital games on mathematics attitude in primary school. *The Universal Academic Research Journal, 6*(4), 202–213.

Field, A. (2018). *Discovering statistics using IBM SPSS statistics* (5th ed.). SAGE.

Gui, Y., Cai, Z., Yang, Y., Kong, L., Fan, X., & Tai, R. H. (2023). Effectiveness of digital educational game and game design in STEM learning: a meta-analytic review. *International Journal of STEM Education, 10*(1), 36.

Guro, M. C., & Corpuz, R. M. (2025). Gamification learning strategies on learners' performance in mathematics. *LORO Education and Management Sciences Journal, 5*(1), 22–31. https://lorojournals.com/index.php/emsj/article/view/1297

Plass, J. L., Mayer, R. E., & Homer, B. D. (2015). *Handbook of game-based learning*. MIT Press.

Ruiz, J. J. R., Sanchez, A. D. V., & Figueredo, O. R. B. (2024, December). Impact of gamification on school engagement: A systematic review. *In Frontiers in Education* (Vol. 9, p. 1466926). Frontiers Media SA.

Sappaile, P. (2024). The impact of gamification learning on student motivation in elementary school learning. *International Journal of Education Research and Curriculum Development, 6*(3), 44–52. https://www.researchgate.net/publication/382620311.