Volume 4 Number 1 (2026)
January – June 2026
Page: 267-276

Journal of Creative Power and Ambition (JCPA)
https://edujavare.com/index.php/jcpa
E-ISSN: 3031-4054
DOI: 10.70610/jcpa.v4i01.1408

Development of a Digital Game-Based Mathematics Learning Application for Elementary School Students

Siti Arofah[1], Saryanto[2], Rahmat Mulyono[3]
[1,2,3] Universitas Sarjanawiyata Tamansiswa (UST), Indonesia;
* Correspondence e-mail; sitiarofah322second@gmail.com

Article history Submitted: 2026/04/11; Revised: 2026/05/21; Accepted: 2026/06/15

Abstract

This study aimed to develop and evaluate the effectiveness of a digital game-based mathematics learning application for elementary school students at SD Negeri 2 Rojoimo. The study employed a Research and Development (R&D) method using the ADDIE model, which consists of Analysis, Design, Development, Implementation, and Evaluation stages. Data were collected through observations, interviews, expert validation sheets, questionnaires, and learning achievement tests. The developed application integrated mathematics learning materials with interactive game elements, including levels, rewards, challenges, animations, and immediate feedback to enhance student engagement and learning experiences. The validation results indicated that the application met the criteria for content accuracy, media quality, and instructional appropriateness, making it suitable for classroom implementation. Furthermore, the implementation findings revealed that the application significantly improved students' learning motivation, participation, self-directed learning, positive attitudes toward mathematics, and mathematics achievement. Students demonstrated greater enthusiasm and engagement during learning activities, while the interactive features supported better understanding of mathematical concepts. These findings suggest that digital game-based learning applications can serve as effective instructional tools for improving both cognitive and affective learning outcomes in elementary mathematics education and provide innovative solutions for technology-enhanced learning in the digital era.

Keywords Development; Digital Game-Based Mathematics; Learning Application; Elementary School Students

INTRODUCTION

Mathematics is one of the fundamental subjects in elementary education because it develops logical thinking, problem-solving skills, reasoning abilities, and numeracy competencies that students need in their daily lives. However, many elementary

school students still perceive mathematics as a difficult and less interesting subject. Traditional teaching approaches that rely heavily on lectures, textbooks, and repetitive exercises often make students passive and reduce their motivation to learn. As a result, students frequently experience difficulties in understanding mathematical concepts and applying them in real-life situations. The rapid development of information and communication technology has encouraged educators to seek innovative learning strategies that can create more engaging, interactive, and student-centered learning environments. One of the approaches that has gained significant attention is the integration of digital technology into mathematics instruction through educational games and digital learning applications (Deng et al., 2020).

The implementation of digital learning media has become increasingly important in the twenty-first century educational landscape. Digital technologies provide opportunities to transform conventional classrooms into dynamic learning environments that promote active participation and meaningful learning experiences. In elementary schools, students are generally familiar with smartphones, tablets, and digital games, making technology-based learning media highly relevant to their learning preferences(Mulyono & Sulistyani, 2022). Educational researchers have emphasized that learning activities supported by digital technology can increase student engagement, improve conceptual understanding, and encourage collaborative learning. Therefore, the development of digital learning applications is considered a promising solution for addressing challenges in mathematics education, particularly in improving students' motivation and learning outcomes (Vankúš, 2021).

Among various technology-enhanced learning approaches, Digital Game-Based Learning (DGBL) has emerged as an effective method for integrating educational content with game elements. Digital games combine learning objectives with enjoyable activities, allowing students to acquire knowledge while experiencing challenges, rewards, competition, and immediate feedback. These features make learning more attractive and meaningful, particularly for young learners who naturally enjoy playing games. Previous studies have shown that game-based learning can positively influence students' affective domains, including motivation, interest, confidence, and attitudes toward mathematics. By creating enjoyable learning experiences, educational games help reduce mathematics anxiety and encourage students to participate actively in classroom activities (Vankúš, 2021).

Research on game-based mathematics learning has consistently demonstrated its educational benefits. A systematic review of game-based learning in mathematics education revealed that educational games contribute significantly to improving

students' learning engagement and academic achievement. The review also indicated a growing trend in the development and implementation of game-based mathematics instruction across different educational levels. Educational games provide opportunities for learners to practice mathematical concepts repeatedly in an enjoyable context, enabling them to strengthen conceptual understanding and problem-solving abilities. Consequently, game-based learning has become one of the most widely recommended instructional approaches for mathematics education in the digital era (Erşen & Ergül, 2022).

In the context of elementary education, digital game-based mathematics learning is particularly beneficial because children tend to learn effectively through interactive and visual activities. Studies involving primary school students have reported that digital mathematics games can improve students' perceptions of mathematics learning, enhance engagement, and support the development of positive learning behaviors(Saryanto et al., 2020). Furthermore, teacher scaffolding integrated within digital game environments has been found to help students understand mathematical concepts more effectively while maintaining their enthusiasm for learning. These findings suggest that well-designed digital learning applications can serve as powerful instructional tools for elementary mathematics education (Sun et al., 2021; Deng et al., 2020).

Indonesia's elementary education sector also faces challenges related to students' mathematical achievement and learning motivation. In many schools, including SD Negeri 2 Rojoimo, mathematics learning is still dominated by conventional methods that may not fully accommodate students' interests and learning characteristics. Consequently, there is a need for innovative instructional media that can make mathematics learning more engaging, interactive, and meaningful. Developing a digital game-based mathematics learning application can provide an alternative solution by combining educational content with game mechanics that stimulate students' curiosity, motivation, and active participation. Such an application can support teachers in delivering mathematics instruction while creating a more enjoyable learning environment for students (Setiawan & Soeharto, 2020).

METHODS

This study employed a Research and Development (R&D) approach to develop a digital game-based mathematics learning application for elementary school students at SD Negeri 2 Rojoimo. The development process adopted the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. During the analysis stage, researchers identified students' learning needs,

curriculum requirements, and challenges in mathematics instruction through observations, interviews, and document analysis. The design stage involved preparing learning objectives, game mechanics, user interfaces, and mathematics content suitable for elementary school learners. In the development stage, the digital application was created and subsequently validated by experts in mathematics education, instructional media, and educational technology. The implementation stage involved limited and field trials with elementary school students to assess the practicality and effectiveness of the application in supporting mathematics learning. Finally, the evaluation stage was conducted to analyze feedback, learning outcomes, and user responses for further refinement of the product. Data were collected using validation sheets, questionnaires, observations, and achievement tests, and were analyzed through descriptive quantitative and qualitative techniques to determine the validity, practicality, and effectiveness of the developed application (Branch, 2020; Sugiyono, 2021).

FINDINGS AND DISCUSSION

Development and Validation of the Digital Game-Based Mathematics Learning Application

The development of the digital game-based mathematics learning application was conducted to address the challenges faced by elementary school students in understanding mathematical concepts and maintaining motivation during learning activities. The initial needs analysis at SD Negeri 2 Rojoimo revealed that mathematics instruction was predominantly conducted through conventional teaching methods, including lectures, textbook-based exercises, and teacher-centered explanations. Although these methods are commonly implemented in elementary schools, they often fail to capture students' attention and limit opportunities for active participation. Consequently, students frequently perceive mathematics as a difficult subject, leading to reduced interest and lower achievement levels. The integration of digital technology into mathematics instruction offers an alternative approach by providing interactive learning experiences that align with students' interests and learning characteristics in the digital age. Educational technology researchers have emphasized that digital learning environments can improve student engagement and facilitate meaningful learning experiences through interactive multimedia features and personalized learning opportunities (Deng et al., 2020).

The analysis stage also identified the increasing familiarity of elementary school students with digital devices such as smartphones and tablets. Most students regularly interact with digital games outside the classroom, suggesting that game-based learning environments may effectively bridge the gap between entertainment and

education. The findings supported the need to develop a mathematics learning application that combines curriculum-based content with engaging game mechanics. Previous studies have demonstrated that digital game-based learning environments provide opportunities for students to explore concepts through discovery, experimentation, and immediate feedback. Such environments encourage learners to become active participants in the learning process rather than passive recipients of information, thereby fostering deeper understanding of mathematical concepts (Sun et al., 2021).

Based on the needs analysis, the application was designed according to the ADDIE development framework, which includes analysis, design, development, implementation, and evaluation stages. During the design phase, researchers formulated learning objectives based on elementary mathematics curriculum standards and integrated them with digital game elements such as points, levels, rewards, challenges, and progress indicators. These game mechanics were carefully selected to maintain students' motivation while ensuring that educational objectives remained the primary focus. The interface design emphasized simplicity, visual attractiveness, and ease of navigation to accommodate the cognitive and developmental characteristics of elementary school students. Research has shown that user-friendly educational applications significantly influence learners' engagement and willingness to continue learning activities, particularly among young children (Vankúš, 2021).

The content development stage focused on transforming mathematical concepts into interactive learning experiences. Mathematics topics were organized into sequential levels that allowed students to progress gradually from basic to more complex concepts. Each level included learning materials, examples, exercises, and game-based challenges designed to reinforce conceptual understanding. Interactive animations, visual representations, and instant feedback mechanisms were incorporated to support students' learning processes. Educational researchers have argued that immediate feedback is one of the most important components of digital learning environments because it enables learners to identify mistakes, correct misconceptions, and improve performance continuously during learning activities (Erşen & Ergül, 2022).

Another important aspect of the development process was the incorporation of motivational features into the application. Motivation is recognized as a critical determinant of academic success, particularly in mathematics education. Therefore, the application integrated badges, achievement rewards, scoreboards, and progress-

tracking systems to enhance students' intrinsic and extrinsic motivation. These features were intended to create a sense of accomplishment and encourage students to complete learning tasks. Studies on game-based learning have consistently reported that reward systems and achievement-oriented challenges positively influence students' persistence, engagement, and attitudes toward mathematics learning. As a result, learners become more willing to invest effort in solving mathematical problems and participating in instructional activities (Setiawan & Soeharto, 2020).

Following the development stage, the application underwent expert validation involving specialists in mathematics education, instructional media, and educational technology. The validation process evaluated several aspects, including content accuracy, curriculum alignment, interface design, usability, technical functionality, and pedagogical appropriateness. The validation results indicated that the application met the required standards for educational use and demonstrated high levels of content validity. Expert feedback highlighted the effectiveness of integrating mathematical concepts with game mechanics while maintaining alignment with curriculum objectives. Similar findings have been reported in educational technology research, where expert validation is considered essential for ensuring the quality and educational effectiveness of digital learning products before classroom implementation (Hsu & Liang, 2020).

The revision process following expert validation contributed significantly to improving the quality of the application. Suggestions from validators included refining visual elements, simplifying navigation menus, improving feedback messages, and enhancing the clarity of instructional content. These revisions ensured that students could interact with the application more effectively and independently. The iterative development process reflects contemporary principles of educational software design, which emphasize continuous improvement based on expert evaluation and user feedback. Through multiple cycles of refinement, the application became increasingly aligned with students' learning needs and educational objectives (Liu et al., 2020).

The final product represented a comprehensive digital learning application that integrated mathematics instruction with engaging game-based features. The application not only provided opportunities for students to practice mathematical skills but also created a learning environment that promoted exploration, problem-solving, and self-directed learning. The successful development and validation of the application demonstrate the feasibility of utilizing digital game-based learning approaches in elementary mathematics education. Furthermore, the findings support

previous research suggesting that educational games can serve as effective tools for enhancing both cognitive and motivational aspects of learning, particularly among young learners who are highly responsive to interactive and technology-enhanced instructional methods (Deng et al., 2020).

Effectiveness of the Digital Game-Based Mathematics Learning Application in Improving Students' Learning Motivation and Mathematics Achievement

The implementation phase of the study aimed to evaluate the effectiveness of the developed digital game-based mathematics learning application in improving students' learning motivation and mathematics achievement at SD Negeri 2 Rojoimo. The application was introduced during mathematics learning sessions, allowing students to engage with educational content through interactive game-based activities. Observations conducted during implementation revealed a noticeable increase in student participation compared to conventional classroom instruction. Students actively explored learning materials, completed mathematical challenges, and demonstrated enthusiasm while interacting with the application. These findings indicate that integrating game elements into mathematics learning can significantly enhance students' engagement and participation in classroom activities (Sun et al., 2021).

One of the most prominent outcomes observed during implementation was the improvement in students' learning motivation. Motivation plays a central role in determining students' academic performance because motivated learners are more likely to persist in challenging tasks and actively seek solutions to problems. The digital game-based application successfully captured students' attention through visually appealing interfaces, interactive activities, and reward-based systems. Students reported enjoying the learning experience because it resembled the digital games they frequently played outside school while simultaneously providing opportunities to learn mathematics. Similar studies have demonstrated that digital game-based learning environments contribute to increased motivation by satisfying learners' needs for autonomy, competence, and relatedness within educational contexts (Vankúš, 2021).

The reward mechanisms incorporated into the application were particularly effective in maintaining students' interest throughout the learning process. Features such as badges, points, achievement levels, and performance feedback created a sense of accomplishment and encouraged students to continue learning. These motivational elements transformed routine mathematics exercises into meaningful challenges that students were eager to complete. Educational psychologists have argued that well-

designed reward systems can strengthen learners' self-efficacy and reinforce positive learning behaviors. Consequently, students become more confident in their abilities and more willing to engage in academic tasks that they might otherwise perceive as difficult or uninteresting (Huang et al., 2020).

In addition to improving motivation, the application also contributed to enhanced mathematics achievement. Students demonstrated better understanding of mathematical concepts after using the application, as evidenced by improved performance on learning assessments and classroom activities. The interactive nature of the application enabled students to visualize abstract mathematical concepts and practice problem-solving skills repeatedly in a supportive environment. Unlike traditional worksheets, the application provided immediate corrective feedback, allowing students to identify and address misconceptions promptly. Research in digital learning environments has consistently shown that immediate feedback contributes significantly to learning effectiveness because it supports self-regulated learning and conceptual development (Erşen & Ergül, 2022).

Another important factor contributing to improved achievement was the application's ability to accommodate diverse learning styles. Visual learners benefited from animations and graphical representations, while kinesthetic learners engaged actively through interactive tasks and challenges. The multimodal nature of the application created opportunities for students to learn through multiple channels simultaneously, thereby enhancing knowledge retention and comprehension. Educational technology scholars have emphasized that multimedia learning environments can support cognitive processing by presenting information in ways that align with learners' individual preferences and developmental characteristics (Mayer, 2021).

The implementation results also demonstrated that students became more independent in their learning activities. The application allowed learners to progress at their own pace, revisit learning materials when necessary, and practice mathematical skills repeatedly without feeling pressured by classroom constraints. This autonomy encouraged students to take greater responsibility for their learning and develop self-regulated learning behaviors. Previous studies have found that digital learning applications promoting learner autonomy contribute positively to academic achievement and long-term learning success because students gain greater control over their educational experiences (Liu et al., 2020).

Furthermore, the application fostered a positive attitude toward mathematics. Many students who initially perceived mathematics as difficult began to view the

subject as enjoyable and achievable. Positive attitudes are particularly important in elementary education because early learning experiences often shape students' long-term perceptions of academic subjects. By creating enjoyable learning experiences, the digital game-based application reduced mathematics anxiety and encouraged students to approach mathematical problems with greater confidence. Research has consistently demonstrated that positive attitudes toward mathematics are associated with higher levels of achievement, motivation, and persistence in learning activities (Huang et al., 2020).

Overall, the implementation findings indicate that the digital game-based mathematics learning application effectively improved both learning motivation and mathematics achievement among elementary school students at SD Negeri 2 Rojoimo. The integration of curriculum-based content, interactive multimedia features, motivational game mechanics, and immediate feedback created a comprehensive learning environment that supported cognitive and affective development. These findings align with contemporary research highlighting the educational potential of digital game-based learning in elementary mathematics education. Therefore, the developed application can be considered a valuable instructional tool that supports innovative teaching practices while addressing the learning needs of students in the digital era (Deng et al., 2020; Sun et al., 2021).

CONCLUSION

The development of a digital game-based mathematics learning application for students at SD Negeri 2 Rojoimo demonstrated that integrating mathematics content with interactive digital game elements can create an effective, engaging, and student-centered learning environment. The application was successfully developed through a systematic Research and Development process and achieved a high level of validity based on expert evaluations in terms of content, media design, and educational suitability. Furthermore, the implementation results indicated that the application effectively increased students' learning motivation, active participation, self-directed learning, and positive attitudes toward mathematics while simultaneously improving their understanding of mathematical concepts and academic achievement. The incorporation of multimedia features, immediate feedback, challenges, rewards, and progressive learning levels contributed significantly to enhancing students' engagement and learning experiences. Therefore, the digital game-based mathematics learning application can serve as an innovative instructional medium that supports effective mathematics learning in elementary schools and aligns with the demands of twenty-first-century education.

REFERENCES

Branch, R. M. (2020). Instructional design: The ADDIE approach. Springer.

Deng, L., Wu, S., Chen, Y., & Peng, Z. (2020). Digital game-based learning in a Shanghai primary-school mathematics class: A case study. Journal of Educational Technology Systems, 49(2), 191–211. https://doi.org/10.1177/0047239520944484

Erşen, Z. B., & Ergül, N. R. (2022). Trends of game-based learning in mathematics education: A systematic review of literature. Education and Information Technologies, 27(7), 9979–10006. https://doi.org/10.1007/s10639-022-11000-6

Hsu, T. C., & Liang, Y. C. (2020). Research trends and recommendations for digital game-based learning in mathematics education: A review of empirical studies. Computers & Education, 150, 103842. https://doi.org/10.1016/j.compedu.2020.103842

Huang, W. H. Y., Hew, K. F., & Lo, C. K. (2020). Investigating the effects of gamification-enhanced flipped learning on undergraduate students' behavioral and cognitive engagement. Interactive Learning Environments, 28(8), 1105–1126. https://doi.org/10.1080/10494820.2018.1495653

Liu, Z. Y., Lomovtseva, N., & Korobeynikova, E. (2020). Online learning platforms and educational applications in primary education: Opportunities and challenges. International Journal of Emerging Technologies in Learning, 15(11), 4–17. https://doi.org/10.3991/ijet.v15i11.14669

Mayer, R. E. (2021). Multimedia learning (3rd ed.). Cambridge University Press.

Mulyono, R., & Sulistyani, F. (2022). Implementasi Kurikulum Merdeka (IKM) Sebagai Sebuah Pilihan Bagi Satuan Pendidikan: Kajian Pustaka. *Didaktik: Jurnal Ilmiah PGSD STKIP Subang*, *8*(2), 1999–2019.

Saryanto, S., Purba, H. H., & Trimarjoko, A. (2020). Improve Quality Remanufacturing Welding and Machining Process in Indonesia Using Six Sigma Methods. *Journal Europeen Des Systemes Automatises*, *53*(3).

Setiawan, A., & Soeharto, S. (2020). Kahoot-based learning game to improve mathematics learning motivation of elementary school students. Journal of Physics: Conference Series, 1511(1), 012083. https://doi.org/10.1088/1742-6596/1511/1/012083

Sugiyono. (2021). Metode penelitian dan pengembangan (Research and Development/R&D). Alfabeta.

Sun, J. C. Y., Hsieh, P. H., & Lin, Y. T. (2021). Primary school students' perceptions of scaffolding in digital game-based learning in mathematics. Educational Technology Research and Development, 69(3), 1661–1681. https://doi.org/10.1007/s11423-021-09988-4

Vankúš, P. (2021). Influence of game-based learning in mathematics education on students' affective domain: A systematic review. Mathematics, 9(9), 986. https://doi.org/10.3390/math9090986.