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DEVELOPMENT OF AN EDUCATIONAL MATHEMATICS GAME TO ENHANCE MOTIVATION AND LEARNING ACTIVITY OF ELEMENTARY SCHOOL STUDENTS

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Abstract

This study aims to develop an educational game as a mathematics learning medium for elementary schools to enhance students' motivation and learning activity. Many pupils struggle to grasp fundamental mathematical concepts due to low enthusiasm and limited engagement in the learning process, which renders lessons tedious. The research method follows the five stages ADDIE model, encompassing analysis to identify factors underlying low motivation and activity, design to draft a game concept aligned with elementary students' characteristics, development to produce a prototype using Wordwall and Canva, implementation to conduct field trials in an elementary school, and evaluation to assess the game's effectiveness in boosting motivation and engagement. The fourth-grade students at SD Negeri Pasirian 05, comprising 27 students, were employed as the research subjects. The study developed a mathematics educational game using the ADDIE model, with Wordwall and Canva as platforms, and found the resulting media to be valid and feasible based on expert assessments. Classroom implementation showed that the game effectively increased fourth-grade students' motivation and learning activity at SD Negeri Pasirian 05. In addition, these findings implied that integrating game-based learning media designed with Wordwall and Canva can be a practical and effective strategy for primary school teachers.

Keywords: Activities; ADDIE Model; Educational Games; Motivation

Abstrak

Penelitian ini bertujuan untuk mengembangkan sebuah permainan edukatif sebagai media pembelajaran matematika di sekolah dasar guna meningkatkan motivasi dan keterlibatan belajar siswa. Banyak peserta didik kesulitan memahami konsep dasar matematika karena rendahnya antusiasme dan keterlibatan dalam proses pembelajaran, sehingga pelajaran terasa membosankan. Metode penelitian mengikuti lima tahap model ADDIE, meliputi analisis untuk mengidentifikasi faktor penyebab rendahnya motivasi dan aktivitas, desain untuk merancang konsep permainan yang sesuai dengan karakteristik siswa sekolah dasar, pengembangan untuk menghasilkan prototipe menggunakan Wordwall dan Canva, implementasi untuk melakukan uji coba lapangan di sekolah dasar, serta evaluasi untuk menilai efektivitas permainan dalam meningkatkan motivasi dan keterlibatan. Subjek penelitian adalah siswa kelas IV SD Negeri Pasirian 05 yang berjumlah 27 orang. Penelitian ini mengembangkan sebuah permainan edukasi matematika menggunakan model ADDIE dengan platform Wordwall dan Canva, dan hasilnya menunjukkan bahwa media yang dihasilkan valid serta layak berdasarkan penilaian para ahli. Implementasi di kelas membuktikan bahwa permainan tersebut efektif dalam meningkatkan motivasi dan aktivitas belajar siswa kelas IV di SD Negeri Pasirian 05. Selain itu, temuan ini mengimplikasikan bahwa integrasi media pembelajaran berbasis permainan yang dirancang dengan Wordwall dan Canva dapat menjadi strategi praktis dan efektif bagi guru sekolah dasar.

***Kata kunci**: Aktivitas; Game Edukatif; Model ADDIE; Motivasi.*

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INTRODUCTION

Elementary mathematics learning nowadays is often perceived by students as difficult and unengaging (Amalia & Utama, 2025). Low enthusiasm and minimal active involvement in the learning process, particularly on foundational topics such as multiplication, render the material monotonous and dull, thereby impacting learning motivation (Lubis et al., 2023). Moreover, systematic reviews indicate that negative perceptions of mathematics contribute to diminished interest in learning and lower academic achievement in subsequent educational stages (Yeribatuah & Arthur, 2023). Therefore, innovative instructional strategies are required to enhance student engagement and motivation from an early age (Li et al., 2025).

In this case, advances in educational technology have opened new possibilities for teachers to create engaging, meaningful learning experiences for elementary students. These technological improvements in education have made life easier for students (Haleem et al., 2022). One rapidly evolving strategy is the utilization of educational games as instructional media. This medium can present mathematical content in a contextualized manner, spark curiosity, and foster both collaboration and critical thinking among students (Nurhikmah et al., 2024). In addition, providing these alternative pedagogical media can enhance engagement and relevance in mathematics education (Lazarinis, 2025).

In addition, integrating game-based learning these days can be an alternative media to promote mathematics instruction. Gamification nowadays has emerged as a powerful catalyst for transforming conventional learning into a more dynamic and student-centered experience (Prasetyo & Meiliasari, 2025). This can be applied across various instructional activities, transforming routine classroom tasks into engaging challenges. Integrating games into Mathematics instruction can also be applied across various instructional activities, transforming routine classroom tasks into engaging challenges (Mursalin et al., 2024).

Based on the results of the observation during the pedagogical practices in SD Negeri Pasirian 05, it was found that most students had low learning motivation and engagement. Meanwhile, in terms of limited digital infrastructure, such as uneven internet connectivity and a shortage of computers or tablets, along with teachers' low readiness to operate technological media, constitute the primary (Viberg et al., 2020); (Suprianto et al., 2025).

In addition, most teachers tend to use traditional pedagogical approaches in classroom learning. These conventional approaches seem to fail to attract students' interest during the lesson. This also leads to lower students' attitudes toward mathematics. In addition, this can promote students' perception that mathematics lessons are always considered boring.

To address these issues, integrating game-like learning into mathematics instruction promotes more engaging and interactive learning activities. Engaging students in mathematics learning activities through a game can interestingly promote students' learning (Mardeli et al., 2025). Additionally, the interactivity and instant feedback provided by educational games help learners recognize errors and reinforce the concepts they are studying.

Previous studies have shown the positive impact of integrating games into Mathematics learning. (Ong & Toh, 2024) found that proper implemen-

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tation of gamification in mathematics classrooms can positively impact students' attitudes and behaviour towards learning mathematics. In addition, there was a significant increase in student learning outcomes, especially in problem-solving abilities involving the application of mathematical concepts in real life (Hayati, 2025).

Despite the potential of involving games in mathematics instruction, this research seeks to address the gap in the previous studies. This research provides a novelty in dealing ADDIE model in integrating games into mathematics learning. This study aims at developing an ADDIE-based educational mathematics game for fourth-grade students at SD Negeri Pasirian 05, evaluating the media's validity through expert assessment, and analyze its impact on students' motivation and learning activity.

In addition, by incorporating students at the center of the design and validation process, the developed media is expected to be both pedagogically and technically sound and to effectively enhance engagement, motivation, and mathematics achievement. This also ensures that the tools created are not only technically reliable but also pedagogically relevant to their needs.

METHODS

This study employed a Research and Development (R&D) design with ADDIE model. This ADDIE Model for conceptualizing learning systems. This model can be used for various types of development products in learning activities. In this case, the ADDIE model is a learning design model consisting of five stages: analysis, design, development, implementation, and evaluation.

The study was conducted with fourth-grade students, consisting of 27 students at SD Negeri Pasirian 05. Moreover, the class was selected purposively to ensure representativeness in terms of classroom dynamics and teacher readiness. The data were collected through observation, questionnaires, and semi-structured interviews.

In addition, the study used a structured observation sheet designed to capture students' learning conditions, including indicators such as students' level of participation during mathematics lessons, students' engagement, and students' attention and attitude toward the learning media. Meanwhile, interviews were conducted with a selection of students to explore their feelings, difficulties, and expectations in mathematics learning.

Furthermore, the ADDIE model incorporated in this study was proposed by Umam et al. (2024).

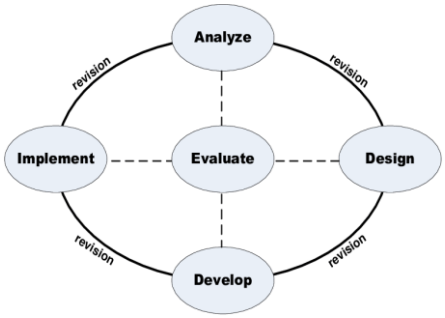

Figure 1. The Stages of ADDIE Model

The analysis phase dealt with identifying students' needs and characteristics, as well as identifying key factors contributing to low student motivation and engagement, including technical barriers, students' perceptions, and teacher readiness. The data were collected through structured observation and in-depth interviews. These were then fully transcribed and analyzed using thematic analysis to ensure the trustworthiness of the findings.

Additionally, the designing phase dealt with integrating fourth-grade mathematics content into interactive and relevant game mechanics. In this case,

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the mathematical material was constructed to emphasize single-digit and two-digit multiplication concepts in line with the fourth-grade curriculum. In addition, the game storyboard was organized into five progressive levels that combine drag-and-drop activities and matching multiplication results.

Further, the interface design was optimized using Canva so that each visual element supports students' under-standing without adding cognitive load (Boateng et al., 2018). In addition, the development phase was dealing with creating a game prototype usingthe Wordwall platform and supported by visual assets from Canva. The product was then validated by the experts or validators dealing with the content of the products, proposed by (Ananda & Sari, 2025) and (Anggraeni et al., 2025).

Three expert validators, namely a language specialist, a media design specialist, and a mathematics specialist, then evaluated language clarity, visual presentation quality, and content align-ment with curriculum standards. This validation employed a learning media validation instrument, and each aspect was validated with a minimum threshold score of 85 percent before proceeding to field testing (Rakasiwi & Muhtadi, 2021). In addition, this validation employed a learning media validation instrument, and each aspect was validated with a minimum threshold score of 85 percent before proceeding to field testing (Rakasiwi & Muhtadi, 2021).

Once it was validated by the experts, the product was implemented into classroom learning practice. This phase evaluated the media's feasibility through a field trial conducted at SD Negeri Pasirian 05. During this phase, the prototype was deployed over a two-week period with game sessions lasting one class period (45 minutes) at each meeting. Moreover, pre-intervention and post-intervention obser-vations were used to compare student participation patterns between conventional instruction and game-based learning.

Then, the evaluation phase dealt with measuring its effectiveness on students' motivation and learning activity using qualitative instruments combined to assess the effectiveness of the media. Operationally, this phase includes follow-up data analysis regarding classroom observation and semi-structured interviews. These were used to measure the effectiveness of the educational game in improving student motivation and learning activity.

Lastly, in this data analysis technique, the students' responses on the motivation questionnaire were scored and then converted to percen-tages at the indicator level, analysing pre-post comparison, and conducting triangulation of the data. In addition, the limit of the success indicators is above 85% for validation experts, 70–79% for the questionnaire, and above 6/8 on the four-observation rubrics.

RESULTS AND DISCUSSION

This study aims to develop an educational prototype using Wardwall and Canva as a mathematics learning medium for elementary schools to enhance students' motivation and engagement. Further, this study was conducted at SD Negeri Pasirian 05, dealing with 27 fourth-grade students as research subjects. Based on the results of data analysis, it showed that the ADDIE stages conducted in this study were as follows:

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Analysis

The initial phase dealt with identifying the needs, characteristics, and challenges of 4th-grade students at SD Negeri Pasirian 05. This stage involved direct classroom observation and interviews with the 4th-grade teacher at SD Negeri Pasirian 05. Data were gathered through direct classroom observations and interviews with the fourth-grade teacher, allowing the researchers to identify the core challenges affecting the students' learning experiences. The findings indicated that interactive learning media were limited, with teachers predominantly relying on conventional resources. Consequently, students demonstrated low levels of interest and motivation during lessons.

The analysis also revealed that the lack of engaging media directly contributed to students' low motivation and limited active involvement in the classroom. Since the learning process did not offer elements of challenge, enjoyment, or interactivity, many students struggled to stay focused and showed minimal curiosity toward the material. This condition highlighted an urgent need for a learning solution that could address these motivational gaps.

Hence, the researchers concluded that developing game-based learning media using Wordwall and Canva would be a strategic approach to tackle the identified problems. Such media could introduce interactive elements, visual support, and real-time feedback components that were missing in the current classroom conditions. This analysis phase served as the foundation for designing a learning tool tailored to the students' characteristics and needs, intending to increase motivation and learning activity in mathematics lessons.

Design

In this design phase, game-like media were proposed and designed using Wardwall and Canva. This game-like media was designed to increase the students' learning motivation and engagement in mathematics. Additionally, these were based on the results of the data analysis through classical observation and semi-structured interviews to meet the students' needs and characteristics. In addition, his design stage consisted of using appropriate text, images, and videos regarding the materials and contents.

Figure 2. Cover design

Develop

This phase involved collecting and creating images and videos, developing quizzes or game elements, and developing the concept of the games. In addition, Wardwall was used for creating interactive modules, enabling the use of responsive drag and drop quizzes and narrative audio that trigger immediate feedback, allowing students to correct errors promptly. Meanwhile, Canva provided contextual visual assets integrated with the narration.

Moreover, this combination of Canva's visual interface and Wordwall's interactive features has proven capable of sustaining students' focus for longer periods and reducing resistance to mathematical content. Furthermore, before implementation, the prototype underwent expert validation involving assessments of language clarity, visual

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design quality, and content alignment, ensuring the media met feasibility standards and was pedagogically appropriate for fourth-grade learners.

Figure 3. Game instruction

Figure 4. Game level

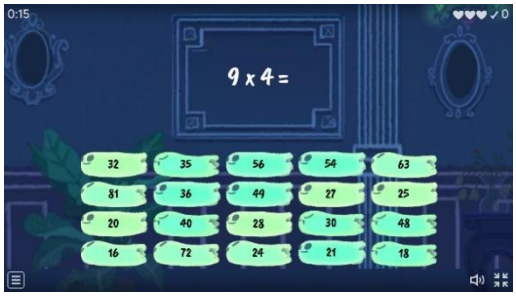

Figure 5. Game challenges

Furthermore, during this phase, the media was also validated by the three validators, Dr. Bekti Sawiji, M.Pd, Feri Dwi Hermawan, S.Pd., and Galih Permadi, M.M., M.Pd. These validations included language, design, and content validations.

Table 2. Result of expert validation

No	Aspect	Score (%)	Description
1	Language	90%	Communicative language, minor revisions for simplification
2	Design	91%	Attractive appearance and easy to use
3	Content	88%	Material aligns with the curriculum and learning context

Based on the data provided in Table 2, it indicates that the language aspect of the product is 90%, and it notes that the problem narratives and instructions were communicative, although some technical terms need adjustment to be more easily understood by fourth-grade students.

Meanwhile, dealing with the content aspect, the score was 88%, stating that the progression from single-digit to two-digit multiplication problems aligns with curriculum standards and is relevant to the local context of SD Negeri Pasirian 05. In addition, the scoring for the design aspect was 91%, indicating the consistency of colors, icons, and interface layout that support intuitive navigation.

Furthermore, these validations by these three experts represented a crucial step in the development process because it ensures that the designed media not only meet technical standards but also are pedagogically relevant and aligned with learner characteristics. Therefore, involvement of experts from different fields helps guarantee that the final product possesses comprehensive quality in terms of both content and form.

Implementation

This implementation phase was conducted with fourth-grade students at SD Negeri Pasirian 05. In this phase,

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the intervention was employed using game-like media incorporated by Wardwall and Canva. The intervention was implemented over two weeks, and each game-based learning session was conducted within a 45-minute class meeting. The teacher facilitated the learning process, ensuring students understood how to navigate the game and supporting them when using the digital media.

Figure 6. Implementing Educational Prototype

Figure 7. Implementing Educational Prototype

In addition, this phase also incorporated classroom observation to see the students' interaction and participation during the teaching-learning process.

Table 3. Result of teacher and students perceptions

No	Respondents	Score (%)	Criteria
1	Students	89	Very positive
2	Teacher	90	Very positive
3	Mean	89,5	Very positive

Based on Table 3, it indicates that both students and teachers had a very positive attitude toward the use of learning media assisted by Wardwall and Canva. It is in line with Susanti et al. (2025) that the Canva-based media proved effective for enhancing mathematical literacy through interactive visual learning. Additionally, the students' motivation also improves during the implementation of learning media.

Table 4. Result of students' motivation analysis

No	Condition	Scoring
1	Before intervention	62.3
2	After intervention	81.7

Tabel 4 revealed a significant increase in student motivation scores. The mean motivation score rose from 62,3 at the pre-intervention stage to 81,7 at the post-intervention stage, a difference of 19,4 points. This finding aligns with Febriyanti et al. (2024) who argue that increased intrinsic motivation can strengthen cognitive engagement and academic performance. In addition, adaptive and positive cognition and attitude towards learning are positively related to learning engagement (Singh et al., 2022); (Lehocká & Kmeťová, 2025).

These findings also underscore the importance of learning media that address students' conditions after the pandemic, when many learners have experienced a motivation gap owing to their reliance on passive and one-way approaches. In this context, offering educational games that are available both in the classroom and during independent sessions creates opportu-nities for exploration as well as challenges that can naturally spark students' interest in learning. Moreover, the media developed serve as visual and cognitive stimuli capable of sustaining learners' attention within a flexible and enjoyable educational environment ((Swider-cios et al., 2023); (Wahyuni & Fitriyani, 2025)).

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Evaluation

The evaluation at this stage was conducted using a motivational questionnaire, which aimed to assess the students' level of motivation regarding the use of prototype-learning media in mathematics learning. In addition, this evaluation has a crucial role in seeing whether the developed prototype media has met the criteria to implement in the classroom learning process and to improve the students' learning motivation.

Table 4. Students' Learning Motivation

No	Indicators	Score (%)	Criteria
1	Learning interest	81%	Highly motivated
2	Focus and independence	86%	Highly motivated
3	Challenge and fun	86%	Highly motivated
4	Mean	84,3%	Highly motivated

The Table 4 indicated that students' average motivation level towards the practical use of prototype media using Wardwall and Canva in mathematics learning was 84.3%, which falls into the "highly motivated" category. This suggests that implementing this game-like prototype using Wardwall and Canva can be a potential medium to promote students' learning motivation ((Wahyuni & Fitriyani, 2025); (Salsabila et al., 2025)).

Furthermore, based on the above results, it reveals that the prototype game using Wordwall serves as the foundation for creating interactive modules, enabling the use of responsive drag and drop quizzes and narrative audio that trigger immediate feedback, allowing students to correct errors promptly ((Yulianto et al., 2024); (Rejabbilaisyah et al., 2024)). Meanwhile, Canva provides contextual visual assets integrated with the narration, thereby reinforcing conceptual understanding through simple yet engaging graphics without adding cognitive load ((Santoso et al., 2022); (Ristanti & Isdaryanti, 2024)).

This platform collaboration yields lightweight media that teachers find easy to use and sufficiently flexible to customize according to classroom needs. In practice, the combination of Canva's visual interface and Wordwall's interactive features has proven capable of sustaining students' focus for longer periods and reducing resistance to mathematical content (Azizah & Ratnaningrum, 2025). These outcomes demonstrate that even basic digital platforms, when designed with sound pedagogical principles, can have a significant impact on learning quality (Tampubolon et al., 2026).

Further discussion highlights the relationship between game design and cognitive load theory. A clean interface, uniform color schemes, and progressive mechanics enable students to process information without distraction, in accordance with the principles of cognitive load theory (Sweller, 2011). The tiered level structure and contextual narrative also combine order with novelty, aligning with the meta-analysis by Kiili (2005) and Oliver (2018). This approach allows learning to occur simultaneously across cognitive, affective, and social domains. Hence, students not only acquire a procedural understanding of mathematical concepts but also engage in a learning process that is enjoyable, challenging, and emotionally meaningful (Weinhandl et al., 2024).

The thematic analysis of interview data identified two primary themes. The first theme, ease of interface navigation,

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enables students to focus on the content without technical distractions. The second theme, the teacher's role as a scaffolder, is crucial in overcoming infrastructural challenges such as limited devices and unstable networks (Mardeli et al., 2025). Teachers provide technical guidance and manage device rotation so that most students enjoy an equitable learning experience. This instructional support also helps prevent students from losing their way while exploring the provided learning media. Moreover, teachers reported that using this media sparked students' interest in independent learning outside of class hours (Attard & Holmes, 2020).

The pedagogical implications of these findings encompass four recommendations. First, the design of educational games should emphasize immediate feedback and level flexibility to address students' motivational needs. Secondly, employing contextual narratives that resonate with learners' environments enhances both engagement and material relevance (Russo et al., 2021). Third, teacher training in scaffolding digital game-based learning must be strengthened. Fourth, a hybrid strategy combining online and offline instruction with small-group device rotation offers a practical solution to infrastructural constraints (Busto & Dumbser, 2021). More broadly, this research can inspire primary education institutions to begin integrating game-based approaches into formal curricula as a form of pedagogical innovation.

This study has several limitations. First, the sample was confined to a single class of 27 students, and the intervention duration was brief, thus not reflecting long-term use. Second, formal cognitive outcome measures on multiplication topics were not conducted, indicating the need for a quasi-experimental design or randomized controlled trial in future research. Moreover, it is recommended to implement adaptive personalization based on learning analytics (Halachev, 2024); (Abbasi et al., 2021); (Plooy et al., 2024). In addition, students with learning difficulties were not analyzed as a separate subgroup, which could offer broader insights into the media's effectiveness for vulnerable populations. Finally, subsequent studies should explore the potential integration of educational games with differentiated instruction approaches to address increasingly diverse individual learning needs.

Overall, the mathematics educational game developed through the ADDIE framework significantly enhanced primary school students' motivation, learning activity, and engagement with multiplication. Moreover, these quantitative and qualitative findings furnish a robust empirical foundation for broader-scale implementation and help bridge the gap between technological potential and classroom practice.

CONCLUSIONS

Based on the research findings, it can be concluded that the development of the game-based mathematics learning media using the ADDIE model successfully produced a feasible and effective learning product for fourth-grade students at SD Negeri Pasirian 05. The media met the feasibility standards for language, visual design, and content, as demonstrated through expert validation scores that exceeded the limit.

Further, classroom intervention showed a clear improvement in students' motivation and learning activity after using the educational game, as reflected in increased questionnaire

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scores and more active participation during learning. In short, this research contributes by producing a validated, interactive mathematics learning media tailored to primary school students' needs and offering a practical digital solution that supports more enjoyable and student-centered mathematics instruction. With these considerations in mind, game-based learning media hold great potential as an innovative solution for teaching mathematics at the elementary level.

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