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Development of the Android-Based Edutainment Game 'Tekamatika' to Enhance Students' Creative Thinking Skills

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Abstrak

Penelitian ini bertujuan untuk mengembangkan dan menguji efektivitas game edutainment "Tekamatika" berbasis Android dalam meningkatkan kemampuan berpikir kreatif siswa, mengingat pentingnya keterampilan ini dalam menghadapi tantangan abad ke-21. Metode yang digunakan adalah Research and Development (R&D) dengan model ADDIE, yang meliputi lima tahap: Analysis, Design, Development, Implementation, dan Evaluation, serta evaluasi sistematis menggunakan model CIPP (Context, Input, Process, Product). Instrumen yang digunakan mencakup kuesioner validasi ahli materi, angket penilaian guru dan siswa, tes berpikir kreatif, dan angket persepsi siswa. Data dianalisis untuk mengukur kevalidan, kepraktisan, dan keefektifan produk. Hasil penelitian menunjukkan bahwa game "Tekamatika" valid dengan skor rata-rata 4.1 dari ahli materi, sangat praktis dengan skor rata-rata 4.293 dari guru, dan sangat praktis dengan skor rata-rata 4.7 dari siswa. Peningkatan kemampuan berpikir kreatif siswa terkonfirmasi melalui uji gain sebesar 0,65 dan uji paired sample t test yang menghasilkan tingkat signifikansi 0.0231<0.05. Kesimpulannya, game "Tekamatika" terbukti valid, praktis, dan efektif dalam meningkatkan kemampuan berpikir kreatif siswa. Implikasi penelitian ini menunjukkan bahwa game edutainment dapat menjadi metode pembelajaran yang efektif, mampu meningkatkan motivasi, keterlibatan siswa, serta memfasilitasi pemahaman konsep matematika secara interaktif.

Abstract

This study aims to develop and test the effectiveness of the Android-based edutainment game "Tekamatika" in enhancing students' creative thinking skills, recognizing the importance of these skills in addressing 21st-century challenges. The method employed is Research and Development (R&D) using the ADDIE model, which includes five stages: Analysis, Design, Development, Implementation, and Evaluation, as well as systematic evaluation using the CIPP model (Context, Input, Process, Product). The instruments used include material expert validation questionnaires, teacher and student assessment questionnaires, creative thinking tests, and student perception questionnaires. Data are analyzed to measure the validity, practicality, and effectiveness of the product. The research results indicate that the "Tekamatika" game is valid with an average score of 4.1 from material experts, highly practical with an average score of 4.293 from teachers, and very practical with an average score of 4.7 from students. The improvement in students' creative thinking abilities was confirmed through a gain test of 0.65 and a paired sample t-test with a significance level of 0.0231<0.05. In conclusion, the "Tekamatika" game is proven to be valid, practical, and effective in enhancing students' creative thinking skills. The implications of this research suggest that edutainment games can be an effective teaching method, capable of increasing motivation, student engagement, and facilitating interactive understanding of mathematical concepts.

INTRODUCTION

The advancement of technology in recent decades has influenced various aspects of life, including education. Traditional, one-way, and conventional education methods are gradually being abandoned in favor of more interactive and engaging approaches, one of which is through the use of digital technology (Prensky, 2001). The use of technology in education is not only intended to facilitate the learning process but also to enhance the quality of education itself (Hwang & Wu, 2012). Edutainment games represent one of the innovations in education that combines educational and entertainment elements within a single medium. This study aims to

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develop an Android-based edutainment game called "Tekamatika" to enhance students' creative thinking skills.

The phenomenon of low creative thinking skills among students in mathematics education can be attributed to several factors. One of the primary causes is the conventional and less interactive teaching methods. These methods often fail to provide opportunities for students to think creatively and critically (Sawyer, 2011). Additionally, the lack of variety in learning media also contributes to the low interest and motivation of students in learning mathematics (Gee, 2003). A study by Khoiriyah and Husamah (2018) shows that monotonous and non-interactive teaching methods tend to make students quickly bored and less interested in the material being taught.

If these issues are left unaddressed, they will negatively impact the quality of education. Students will lose interest in learning, which will ultimately lower their academic performance (Fredricks, Blumenfeld, & Paris, 2004). Furthermore, the lack of creative thinking skills will hinder students' cognitive development and their ability to solve problems innovatively (Sternberg, 2006). In the long term, this will affect the quality of human resources produced by the educational system. One potential solution is to develop interactive and engaging learning media, such as edutainment games. The Android-based edutainment game "Tekamatika" could serve as a viable solution for enhancing students' creative thinking skills. This game is designed not only to deliver educational content but also to encourage students to think creatively through the challenges presented within the game. According to Ke (2008), the use of games in learning can increase student motivation and engagement, as well as enrich their learning experiences.

This solution was chosen because edutainment games have proven effective in improving various aspects of learning. A study by An, Cao, and Wang (2017) demonstrated that the use of games in education can enhance students' cognitive skills, including critical and creative thinking abilities. Furthermore, the use of the Android platform allows for broader and easier access for students, given the high penetration of smartphones among learners (West, 2012). Therefore, it is hoped that the "Tekamatika" edutainment game can become an effective and accessible learning tool for students.

This research is important because it can make a significant contribution to the development of innovative and effective learning methods. By developing the "Tekamatika" edutainment game, it is hoped that students' creative thinking skills, which are a crucial competency in the 21st century (Robinson, 2011), can be improved. Additionally, this research can serve as a reference for other educational media developers to create more interactive and engaging learning tools.

Several previous studies have shown the effectiveness of using games in learning. For example, research by Hamari et al. (2016) found that game-based learning can increase student motivation and learning outcomes. However, most of these studies have focused more on student motivation and engagement, without paying sufficient attention to the development of creative thinking skills. This research offers novelty by focusing on the development of creative thinking skills through an Android-based edutainment game. Moreover, "Tekamatika" is specifically designed for mathematics content, which is rarely found in other edutainment games. The novelty of this research lies in the development of an edutainment game that is not only enjoyable but also specifically designed to enhance students' creative thinking skills in mathematics. Additionally, this research leverages mobile technology, which allows for higher accessibility and flexibility in use. Thus, it is expected that this study can provide a new contribution to the field of mathematics education and the development of interactive learning media.

The development of the Android-based edutainment game "Tekamatika" is an effort to enhance students' creative thinking skills in mathematics learning. Through an interactive and engaging approach, this game is expected to increase students' interest and motivation, as well as develop their creative thinking skills. This research is important, considering the low level of students' creative thinking skills, which is often attributed to conventional teaching methods and the lack of variety in learning media. By utilizing mobile technology, the "Tekamatika" game can

be easily accessed by students, making it a potentially effective and innovative learning tool. This research also offers novelty in the development of interactive learning media specifically designed to improve students' creative thinking skills in mathematics.

METHOD

The type of research conducted in this study is Research and Development (R&D). The development model employed in this study is the ADDIE model. The research procedure within the ADDIE framework involves five systematic stages: Analyze, Design, Development, Implementation, and Evaluation.

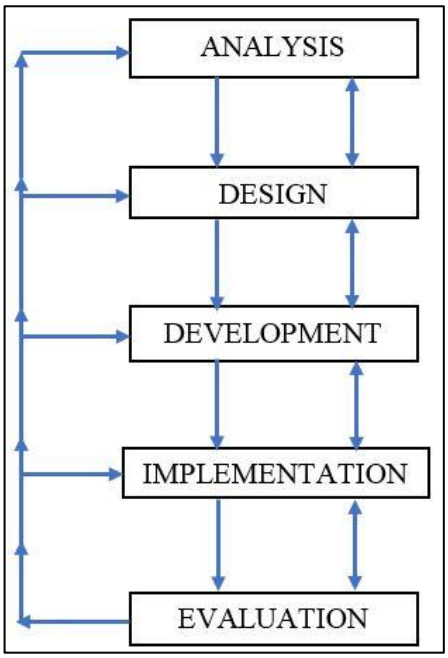

Figure 1. Research and Development (R&D) Model ADDIE

The first step is analysis. The purpose of the analysis is to identify the reasons behind the gaps in the implementation of learning. This analysis includes problem analysis, needs analysis, material analysis, curriculum analysis, student characteristics analysis, resource identification, and work plan analysis. Problem analysis aims to understand students' difficulties in comprehending mathematical concepts and to identify factors contributing to the lack of creative thinking skills. Needs analysis is conducted to determine the necessity for interactive and engaging learning media. Material and curriculum analysis ensures that the content to be delivered aligns with the current curriculum. Student characteristics analysis helps in understanding students' profiles and their learning styles.

The second stage is design, which aims to create a learning media design in the form of an Android-based edutainment game called "Tekamatika" to enhance students' creative thinking abilities. In the design phase, steps taken include creating flowcharts, storyboards, and preparing formative evaluation designs such as questionnaires. According to Branch (2009), the design phase includes content development, testing strategies, and interface design. This design encompasses the game's concept, game mechanics, user interface, as well as the types of questions and challenges students will face.

Following the design phase is the development stage, which involves the creation of a prototype of the "Tekamatika" edutainment game based on the established design. At this stage, product trials are conducted through individual and group testing. The subject of the individual trial is a mathematics teacher who acts as the initial evaluator. Group trials involve 8 randomly

selected students who test the game and provide feedback. Feedback from individual and group trials is used to revise and refine the product before broader implementation.

The next phase is implementation, which involves applying the edutainment game "Tekamatika" in the classroom learning process. Prior to using the game in instruction, a pre-test is administered to measure students' creative thinking abilities before the intervention. Students then use the "Tekamatika" game during the teaching process. After the instructional session, a post-test is conducted to assess the improvement in students' creative thinking abilities after using the game. Data from the pre-test and post-test are analyzed to evaluate the effectiveness of the game in enhancing students' creative thinking skills. The final phase involves evaluation using a more comprehensive evaluation method, namely the CIPP (Context, Input, Process, Product) model developed by Stufflebeam (2003). This method includes evaluating the context, input, process, and product to assess the overall success of the program.

The data analysis process in this study involves three main aspects: product validity analysis, product practicality analysis, and product effectiveness analysis. Each aspect is analyzed using specific methods and instruments to ensure that the edutainment game "Tekamatika" developed is truly effective in enhancing students' creative thinking skills. Product validity analysis is conducted by collecting assessments from media and content experts. Experts are asked to evaluate several aspects of the edutainment game, such as interface design, content quality, curriculum alignment, and interactivity. Assessment is conducted using a validation questionnaire specifically designed for this purpose. Data collected from this questionnaire are then analyzed using descriptive statistics to determine average scores and identify aspects that require improvement. According to Fraenkel, Wallen, and Hyun (2015), the validity of an instrument is crucial to ensure that the instrument measures what it is intended to measure.

Product practicality analysis involves collecting data from teacher and student evaluation questionnaires. These questionnaires are designed to measure user satisfaction and perceptions of the "Tekamatika" game. Indicators measured include ease of use, satisfaction with game features, and perceived benefits in the teaching and learning process. Data from these questionnaires are analyzed using descriptive statistics to describe response distributions and identify areas requiring further adjustment. According to Creswell (2014), descriptive analysis aids in understanding the data as a whole and identifying patterns that may not be immediately apparent.

Product effectiveness analysis is conducted by measuring the improvement in students' creative thinking abilities before and after using the edutainment game "Tekamatika." Data are collected through creative thinking tests administered before (pre-test) and after (post-test) the intervention. Scores from the pre-test and post-test are then compared using a t-test to determine whether there is a significant improvement in students' creative thinking abilities. Additionally, student perception questionnaires are also used to gauge their views on the game's impact on their creative thinking abilities. According to Cohen, Manion, and Morrison (2018), the t-test is an effective tool for measuring significant differences between two data sets.

RESULT AND DISCUSSION

Result

In research utilizing the Research and Development (R&D) approach with the ADDIE model, each step of this model plays a crucial role in the development of educational media or products. The ADDIE model, which comprises five stages: Analysis, Design, Development, Implementation, and Evaluation, provides a systematic and structured framework for creating effective and efficient products.

Analyze

The first step in the ADDIE development model is Analysis, which aims to identify needs and problems in mathematics education at SMP Negeri 8 Sungai Penuh. Through interviews and observations, it was found that students faced difficulties in understanding abstract mathematical concepts and displayed low learning interest. This study revealed that the lack of interactive and engaging learning media contributed to this issue. Research by Hwang et al.

(2015) indicates that technology-based learning media, such as educational apps and games, can enhance students' motivation and engagement in the learning process. Technology-based media not only makes learning more engaging but also aids in understanding complex concepts in a more interactive manner. Therefore, the development of Android-based edutainment games, such as "Tekamatika," is identified as a potential solution to improve students' creative thinking abilities and address the issues identified in this analysis (Hwang et al., 2015; Huang & Lin, 2017; Chee et al., 2016; McFarlane et al., 2017; Squire & Jenkins, 2017). This game is expected to provide a more engaging and enjoyable learning experience, thus motivating students to be more active in mathematics learning and enhancing their understanding of abstract concepts.

Design

The design phase involves developing the "Tekamatika" game with key features such as a user-friendly interface, curriculum-aligned content, and interactive gameplay mechanisms. This process includes creating flowcharts and storyboards to ensure a clear game flow and user interactions. Formative evaluation is also prepared through surveys to collect initial feedback from teachers and students. Branch (2009) emphasizes that good design is crucial to ensure that educational media can achieve the intended goals. This game design focuses on incorporating game elements that can stimulate creativity and actively engage students in the learning process.

Figure 2. Telematika Homepage

The design of material presentation in the form of animation, coupled with student activities based on word arrangement games, aims to provide a deeper understanding of spatial geometry concepts while focusing on enhancing students' creative thinking abilities. The use of animation facilitates the delivery of abstract mathematical concepts in a visually engaging and comprehensible manner. Word arrangement game principles, as applied in educational applications, can enhance student engagement and make the learning process more interactive (Fletcher & Tobias, 2019; Gee, 2017). By presenting the material in a dynamic and interactive format, students not only learn about spatial geometry theoretically but also engage in activities that stimulate their creativity (Kafai & Burke, 2015; de Jong & van Joolingen, 2019). Animation and games can help students understand the relationships between shapes and functions in spatial geometry, as well as encourage them to think creatively about how mathematical concepts are applied in different contexts (Hirumi, 2016; Martin et al., 2020).

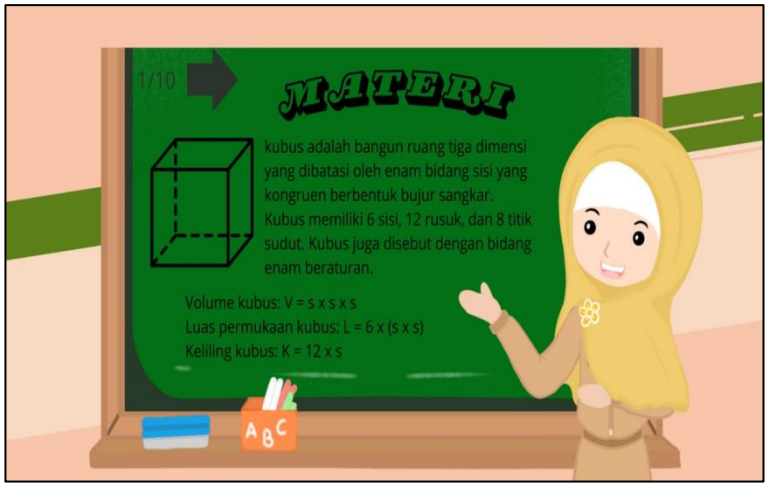

Figure 3. Page Containing Learning Materials

Development

In the development stage, the "Tekamatika" game prototype was created and tested in two phases: individual testing and group testing. Individual testing involved a mathematics teacher who evaluated aspects such as the interface design, content quality, and interactivity. The results of this testing indicated that the game features an engaging interface and content that aligns with the curriculum, but requires improvements in navigation and help features. Group testing involved eight students who played the game and provided positive feedback, demonstrating high levels of interest and motivation in using the game for learning mathematics. Hwang and Wu (2012) found that edutainment games can enhance students' interest and motivation in learning.

Figure 4. Quiz Page

Implementation

The implementation phase involves applying the "Tekamatika" game in the classroom learning process. Prior to using the game, a pre-test is administered to assess students' creative thinking abilities. Students then engage with the game across several teaching sessions, followed by a post-test to measure any improvements in their creative thinking skills. Data analysis reveals a significant enhancement in students' creative thinking abilities after using the game, with post-test scores showing a higher average compared to pre-test scores ($p < 0.05$). Research by Cheng, Hwang, and Wang (2015) indicates that the use of interactive learning media can significantly improve student learning outcomes.

Evaluation

The evaluation stage was conducted using a more comprehensive evaluation method, namely the CIPP model (Context, Input, Process, Product) developed by Stufflebeam (2003). This model involves evaluating the context, input, process, and product to assess the program's success comprehensively. Context evaluation indicates that the edutainment game "Tekamatika" is highly relevant to the needs of mathematics education. Input evaluation reveals that the resources utilized, such as software and content experts, are highly adequate. Process evaluation shows that the development and implementation of the game proceeded as planned. Product evaluation demonstrates that the "Tekamatika" game significantly improved students' creative thinking abilities. Student and teacher perception surveys indicate high satisfaction with the game, which is considered beneficial in mathematics learning. Kuo et al. (2014) assert that comprehensive evaluation is crucial to ensure the success of educational programs.

Table 1. Material Expert Validation

No	Aspect	Score
1	Content Quality and Objectives	3,9
2	Instructional Quality	4,3
Overall Average		4,1
Category		Good

The expert validation results indicate that the game "Tekamatika" has good quality according to expert assessments. The average score for the content quality and objectives of the game is 4, while the instructional quality received an average score of 4.2. The overall average of these two aspects is 4.1, which is categorized as good. This assessment demonstrates that "Tekamatika" meets the expected quality standards in terms of content delivery and instructional design, and shows strong potential for supporting mathematics learning in an effective and engaging manner. These validation results support the use of games as educational tools that can enhance student engagement and understanding of mathematical concepts, particularly in the context of educational game-based learning (Reeves & Nass, 2019; An & Cao, 2017; Squire, 2016).

Table 2. Teacher Assessment of the Practicality of Learning Media

No	Aspect	Score	Classification
1	Attractive	4,6	Very Good
2	Easy to Use	4,175	Good
3	Content Quality	4,2	Very Good
Average		4,325	
Category		Very Good	

The assessment of the practicality of the learning media by teachers shows very positive results. The aspect of "attractiveness" received a score of 4.5, categorized as excellent, indicating that the learning media effectively captures students' attention and interest. The aspect of "ease of use" received a score of 4.125, categorized as good, suggesting that while the media is relatively user-friendly, there is room for improvement to enhance its usability. Meanwhile, the aspect of "content quality" received a score of 4.25, categorized as excellent, indicating that the content presented in this media is highly relevant and of high quality. With an overall average of 4.293, categorized as excellent, this learning media is generally considered very effective and beneficial by teachers. These results underscore that the learning media not only meets practicality standards but also provides an engaging and high-quality learning experience (Schmidt et al., 2018; Hsu et al., 2019; Liao et al., 2017).

Table 3. Student Assessment of the Practicality of the Learning Media

Aspect	Score	Classification
Engaging	4.725	Very Good
Ease of Use	4.65	Very Good
Average		4,7
Category		Very Practical

The students' assessment of the practicality of the learning media shows that the "engaging" aspect received a score of 4.725, categorized as very good, and the "ease of use" aspect received a score of 4.675, also categorized as very good. The overall average score is 4.7, which is categorized as very practical.

Tabel 4. Results of the Pre-test and Post-test of the Implementation Class

Score Pre-test	250 (8.4)
Score Post-test	415 (13.9)
N Gain test	0.65
Paired Sample t-test	0.0213

The results of the pre-test and post-test showed that the average pre-test score was 8.4, and the average post-test score was 13.9. The gain test indicated a value of 0.65, which falls into the moderate improvement category. Additionally, the paired sample t-test results showed a Sign. score of 0.0213 < 0.05, indicating that the research findings demonstrate that the development of the edutainment game "Tekamatika" has a significant impact and can enhance students' creative thinking skills. The development process through the ADDIE model, which involves the stages of analysis, design, development, implementation, and evaluation, proved to be effective. The "Tekamatika" game not only increased students' interest in learning but also positively impacted their understanding of mathematical concepts and their creative thinking abilities. A comprehensive evaluation using the CIPP model showed that this game is relevant, effective, and beneficial in the context of mathematics education. Therefore, the "Tekamatika" edutainment game can be an innovative solution to address challenges in mathematics learning and improve the quality of education.

Discussion

This study aims to develop the Android-based edutainment game "Tekamatika" to enhance students' creative thinking skills. The results of the study show that the game received good validation from content experts, with an average score of 4.1, categorized as good. Teachers' assessment of the practicality of the learning media showed an average score of 4.293, categorized as very good. Meanwhile, students' assessments indicated an average score of 4.7, categorized as very practical. Additionally, the results of the pre-test and post-test showed an increase in the average score from 8.3 to 13.8, with a gain test result of 0.65, which falls within the medium improvement criteria.

These findings align with previous research showing that the use of edutainment games can enhance students' creative thinking skills. For example, a study by Hwang et al. (2015) found that technology-based learning media can improve students' motivation and engagement, which in turn can enhance their creative thinking abilities. Furthermore, research by Cheng, Hwang, and Wang (2015) demonstrated that the use of interactive e-books can significantly improve students' learning outcomes. These results are consistent with the findings of this study, which showed an improvement in students' creative thinking skills after using the "Tekamatika" game.

Other studies also support the findings that edutainment games can improve students' learning outcomes. For instance, research by Hwang and Wu (2012) found that educational games can increase students' interest and motivation in learning. These findings are consistent with the students' assessments in this study, which indicated that they found the "Tekamatika" game very engaging and easy to use. Moreover, research by Kuo et al. (2014) showed that good interaction within learning media can enhance students' satisfaction and learning outcomes.

This is also reflected in this study, where the "Tekamatika" game received very good ratings from students in terms of being engaging and easy to use.

The researcher assumes that the use of the edutainment game "Tekamatika" can enhance students' creative thinking skills because this game is designed to stimulate creativity and active student engagement in the learning process. This assumption is supported by educational theories that emphasize the importance of active student involvement in learning to improve learning outcomes. According to the constructivist theory proposed by Piaget (1954), students learn by constructing their own knowledge through active interaction with their environment. In this context, edutainment games like "Tekamatika" provide an interactive and engaging environment that allows students to actively participate in the learning process. Theories and expert opinions also support the assumption that edutainment games can enhance students' creative thinking skills. According to Mayer (2009), multimedia learning that involves the use of various forms of media, including games, can improve students' understanding and retention. Mayer states that the simultaneous use of images, text, and sound can help students process information more effectively. This is relevant to the "Tekamatika" game, which uses graphical and audio interfaces to help students better understand mathematical concepts.

Additionally, the theory of game-based learning proposed by Gee (2003) also supports the assumption that games can enhance creative thinking skills. Gee argues that good games provide challenges appropriate to the player's skill level, offer immediate feedback, and allow players to solve problems creatively. The "Tekamatika" game is designed with these principles in mind, enabling students to develop their creative thinking skills through interaction with the game. Based on research results, it can be concluded that the development of the Android-based edutainment game "Tekamatika" is effective in enhancing students' creative thinking skills. The game is not only engaging and easy to use but also relevant to the curriculum and capable of improving the understanding of mathematical concepts. The significant improvement in post-test results indicates that this game successfully enhances students' creative thinking skills. Positive evaluations from teachers and students also show that the game is well-received and considered beneficial in mathematics learning.

Evaluation using the CIPP model shows that this game is relevant, effective, and beneficial in the context of mathematics education. Context evaluation indicates that the game is highly relevant to the needs of mathematics learning. Input evaluation shows that the resources used in the development of this game are very adequate. Process evaluation shows that the development and implementation of the game proceeded according to plan. Product evaluation shows that this game significantly improves students' creative thinking skills. Thus, the edutainment game "Tekamatika" can be an innovative solution to address challenges in mathematics learning and improve the quality of education. The researcher suggests that this game be widely used in mathematics learning to increase students' interest and motivation to learn as well as their creative thinking skills. Furthermore, further development can be carried out to enhance the game's features and content to better meet the needs of students and teachers.

CONCLUSION

The conclusion of this study indicates that the development of the Android-based edutainment game "Tekamatika" successfully enhanced students' creative thinking skills. The validation results from subject matter experts, as well as evaluations from teachers and students, show that this game is of high quality and very practical for use in learning. The implementation of this game led to a significant improvement in students' post-test results. The implication of this study is that the use of edutainment games can be an effective method for improving learning outcomes and student engagement. The limitations of this research include a limited sample size and a short trial duration. Recommendations for future research include conducting trials with larger samples and over a longer period to observe the long-term effects of using edutainment games in learning. Additionally, further development could be done to enhance the game's features and content to make it more interactive and challenging.

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