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Gamified Learning Innovation: Enhancing Geometry Education and Student Engagement through Role-Playing Games

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Abstract: This study aimed to develop a role-playing game-based learning medium for teaching flat-sided geometric shapes in mathematics, with the dual objectives of enhancing students' interest and academic performance while meeting the criteria of validity, practicality, and effectiveness. Utilizing a research and development methodology, the study followed several stages: needs analysis, planning, game design and development, validation by media and subject matter experts, iterative revisions, media testing, and final evaluation. The participants included 18 eighth-grade students from Class 8A at SMP Negeri 2 Koba in Kepulauan Bangka Belitung Province, along with mathematics teachers from the same school. Data collection instruments included expert evaluation questionnaires for media and material assessment, a student interest questionnaire, and post-test evaluations. Qualitative data were analyzed by summarizing feedback from experts and students, while quantitative data were derived from questionnaire responses and test results. Validation results showed average scores of 4.51 (out of 5) from media experts and 4.93 (out of 5) from material experts, both categorized as "very good." The student interest questionnaire recorded an average score of 3.54 (out of 5), classified as "good," while post-test results revealed an average score of 80, with 83.33% of students achieving mastery, also classified as "very good." These findings indicate that the role-playing game-based learning medium is valid, practical, and effective in enhancing student interest and academic achievement. The medium is recommended for implementation in junior high school mathematics education, demonstrating significant potential to improve student engagement and learning outcomes.

INTRODUCTION

The rapid advancement of technology in all fields is significantly impacting education. As technology and communication continue to evolve, they will drive further progress and development in the education sector (Abdullah & Yunianta, 2018). Current technological developments can be implemented in education. This can improve the digital learning environment and student performance. The use of technology in education will enable students to learn efficiently and make it easier to track student progress. Learning by utilizing technology can help students prepare for lifelong learning (Haleem et al, 2022).

Education is one of the strategic factors in the future development of a country (Vasile, 2018). This is because education is an important component in

social and economic development (Astakhova et al., 2016). This is also in line with research conducted by Hanushek & Woessmann (2021), where the results of his research showed that the quality of education affects economic outcomes, starting from individual income, income distribution, and economic growth. Education also plays a role in the world of health, where with education people are better prepared to prevent disease and use health services effectively. Education also supports the growth of civil society, democracy, and political stability in a country (The Center for Global Development (CGD), 2002).

The National Council of Teachers of Mathematics NCTM (2000) states that mathematics also has an important role in everyday life, where the need for mathematics in everyday life will always increase. Mathematics is essential for life and supports the overall development of the individual (Hodaňová & Nocar, 2016). Mathematics is one of the disciplines that allows everyone to perform certain calculations in applied science and can obtain applied knowledge (Vinogradova, 2021). In addition, the concept of mathematics is related to other disciplines, such as art and design, design and technology, language, history, geography, economics, science, music, physical education, religious education, and citizenship—all these areas of human development are interrelated with mathematics (Yeasmin, 2017). However, students' mathematical abilities remain relatively low, as reflected in the national achievement data from the Ministry of Education and Culture Kemendikbud (2019), which shows that the average score on the mathematics national exam is lower than in other subjects.

The results of the National Exam (UN) for the 2018/2019 academic year show variations in the average scores of students across four main subjects on a scale of 100. Indonesian recorded the highest average score of 65.59, reflecting relatively strong student proficiency in this subject. Meanwhile, English achieved an average score of 50.23, indicating a moderate level of mastery. The lowest average score was in Mathematics, with 46.56, highlighting significant challenges in understanding this subject. Natural Science (IPA) had an average score of 48.79, slightly better than Mathematics but still below the expected average. Overall, this data emphasizes the need for greater attention to improving student performance, particularly in Mathematics and Natural Science.

The Ministry of Education and Culture (Kemdikbud, 2019) provided additional insights into the performance of students in Mathematics during the 2018/2019 National Exam, specifically highlighting the percentage of correct answers across different learning materials. For the Number category, the national average of correct answers was 39.71%, while Bangka Belitung recorded a slightly lower average of 37.28%, indicating challenges in this area. In the Algebra category, the national average was 51.24%, with Bangka Belitung closely following at 50.59%, reflecting moderate proficiency. In Geometry and Measurements, the national average stood at 42.27%, while Bangka Belitung showed a similar trend with 40.23%, suggesting consistent difficulties in this material. Lastly, in Statistics and Odds, students performed better overall, with the national average reaching 55.60%, slightly lower than Bangka Belitung's 57.46%, indicating stronger comprehension in this area.

Mathematics is a scary subject for most students. This can be seen in class, where mathematics is considered difficult for most students (Langoban, 2020). Mathematics is a subject that makes students anxious; anxiety about mathematics even occurs at elementary school age. Student anxiety about mathematics is due to the risk of failure, difficulty of assignments, time pressure,

and fear of receiving bad grades (Szczygieł & Pieronkiewicz, 2022). Student anxiety in mathematics also has an impact on low student achievement. In addition, one of the factors of students' mathematical anxiety is the academic factor, namely the use of a traditional curriculum, an ineffective teaching style, and the influence of teachers who are anxious about mathematics. (Ruff & Boes, 2014). In addition, based on a survey conducted by Kulkin (2016), 4 out of 5 students stated that mathematics is less enthusiastic, and 3 out of 5 students stated that mathematics is stressful. And 3 out of 5 students do not like solving math problems.

Learning media is a set of tools used for teaching and learning in the fields of science, such as mathematics, science and geography (Maddison et al., 1977). Learning media are tools used to deliver messages that can enhance students' interest in learning and improve the quality of instruction provided by teachers (Farid & Khabibah, 2021). The use of learning media can make learning more effective, make it easier for students to understand and deepen the material, create a coherent understanding, and improve learning outcomes, performance, and student skills (Taha & Abdulrahman, 2023). In education, learning media are often associated with learning resources, teaching aids, and audio-visual aids (AVA) (Suryani et al., 2018). One example of the audio-visual aid (AVA) media developed in this study is a game.

Games are a universal aspect of human culture, present in all societies. They typically involve goals, rules, competition, and active participation (Ifenthaler et al., 2012). In addition, games are also fun, attracting players' interest, time, commitment, and passion (Barab et al., 2010). The implementation of games in the classroom provides potential benefits such as increased motivation, the ability to improve student learning outcomes, increasing enjoyment and excitement in the classroom, and the freedom to fail and try again without negative consequences. The application of games in learning can increase students' interest in learning, encourage students to actively participate in learning, increase motivation, optimize online learning performance, and improve student achievement (Gilyazova & Zamoshchanskii, 2020; Aguiar-Castillo et al; Sümer & Aydın, 2022). Based on this, the use of game-based learning media, such as role-playing games (RPGs), is necessary.

Role-playing games (RPGs) are a series of forms of game styles that involve the creation, representation, and development of characters who interact in a fictional world under a structured rule system (Arenas et al., 2022). In RPGs, the story or plot creation system is episodic and participatory (Mackay, 2017). RPGs are also role-playing games that emphasize rules, player roles, or stories (Arjoranta, 2011). Role-playing games that can be played by one or more players through the perspective of another character with the aim of maximizing the user's experience in the game (Lee et al., 2014) .Role-playing games combine challenge, narrative, and collaboration in the main theme of character and player development (Prager 2019) . Role-playing games (RPGs) are used to present engaging learning materials through animations, images, and sounds, helping to capture students' attention (Farid & Khabibah, 2021). Learning using RPG can significantly improve student learning outcomes (Wu et al., 2016). It is evident that the use of RPG-based learning media in mathematics, particularly on the topic of flat-sided shapes, remains limited. Additionally, there is a lack of RPG-based learning media that specifically addresses students' interest in learning. Therefore, further development of RPG-based learning media is necessary.

The researchers are interested in conducting a study titled 'Game-based

Learning as Mathematics Learning Media to Increase Students' Interest and Learning Achievement.' This research aims to provide valuable solutions to existing challenges in the field of mathematics education.

METHOD

This research adopts a Research and Development (R&D) approach with the primary objective of creating a game-based learning medium for teaching mathematics. The innovative element of this study lies in the use of role-playing games (RPGs), which are designed not only to engage students but also to enhance their academic achievement in mathematics. By integrating interactive and immersive gameplay into the learning process, this approach seeks to address common challenges in maintaining student interest and improving understanding of mathematical concepts.

The methodology in this study follows a systematic sequence of steps adapted from Sugiyono (2013). These steps were modified to meet the unique demands of the research, ensuring both relevance and practicality in the context of mathematics education. The stages include: (1) needs analysis, to identify gaps and opportunities in current teaching practices; (2) planning, which involves designing the RPG framework and aligning it with curriculum objectives; (3) game development, where the RPG is created with attention to educational content and engagement; (4) validation by media and subject matter experts, ensuring the game's technical and pedagogical quality; (5) revision, based on expert feedback to refine the product; (6) media testing, involving direct interaction with students; and (7) feasibility assessment, to evaluate the effectiveness and practicality of the RPG in a real classroom setting.

The participants in this study consisted of 18 students from class VIII-A at SMP Negeri 2 Koba, accompanied by one of the school's mathematics teachers who facilitated the implementation. To ensure a comprehensive evaluation of the game-based learning medium, several instruments were employed. A media evaluation questionnaire was used to gather qualitative and quantitative feedback from media and material experts, focusing on the quality, usability, and alignment of the RPG with educational goals. Additionally, student interest questionnaires measured the level of student engagement and enthusiasm towards the game. Finally, post-tests assessed the impact of the RPG on students' academic performance, providing measurable data on its effectiveness.

This study represents a meaningful contribution to the field of education by combining innovative teaching strategies with rigorous research methodologies. The use of RPGs as a learning medium has the potential to transform mathematics instruction, making it more engaging and effective for students while also offering a replicable model for other subjects and educational settings.

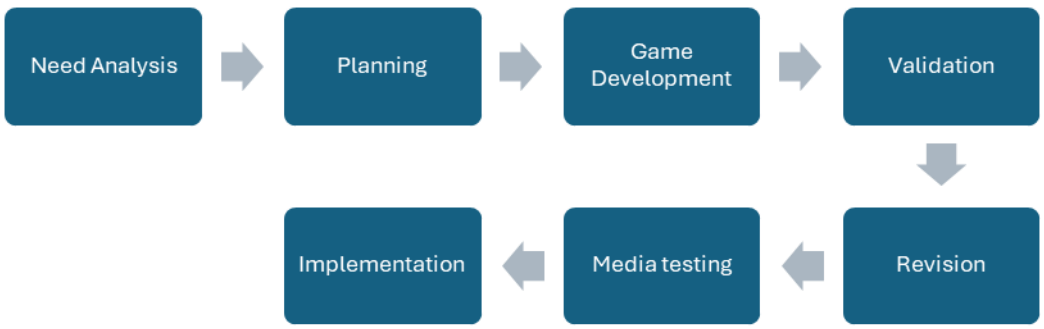

Figure 1. Research Method.

RESULT AND DISCUSSION

The development of game-based learning aims to create a valid, practical, and effective medium for teaching flat-sided geometric materials. This innovative approach is grounded in the Research and Development (R&D) methodology, which involves a series of systematic steps: needs analysis, planning, game development, validation by media and subject matter experts, revision, media testing, and feasibility assessment.

Analysis Phase

The analysis phase is critical as it serves as the foundation for planning the development of the product. This phase includes three sub-analyses: needs analysis, learning materials analysis, and environmental analysis.

The needs analysis ensures that the developed product is both suitable and effective for students at SMP Negeri 2 Koba. Data were collected through observations and interviews with mathematics teachers, revealing a pressing need for new learning strategies that incorporate diverse resources and align with students' learning styles. One recommended strategy is the use of role-playing game (RPG)-based learning media. The popularity of RPGs, particularly Mobile Legends, with over 34 million active monthly players in Indonesia (Racmatanta, 2021), underscores their relevance and appeal among students. Furthermore, in the Bangka Belitung Islands, the annual Mobile Legends tournament, supported by figures such as the Chairperson of E-Sport Indonesia and local officials (Mahendra, 2021), highlights the cultural significance of RPGs in the region. By leveraging this familiarity, RPG-based learning media can capture students' interest while facilitating the visualization of mathematical concepts, making them more accessible and comprehensible. Additionally, the integration of play and education enhances engagement, creating a more enjoyable and effective learning experience.

The learning materials analysis focuses on identifying content that aligns with the school curriculum and meets students' needs. At SMP Negeri 2 Koba, the 2013 curriculum is implemented, which emphasizes competence-based learning. Geometry was selected as the focus for RPG-based learning media due to its reliance on visualization, which is critical for fostering a deeper understanding of its concepts. This alignment ensures that the game-based medium supports curriculum objectives while addressing gaps in traditional teaching methods.

The environmental analysis evaluates the context in which learning occurs, including the availability of resources and the feasibility of implementing the medium. Observations and interviews with the vice principal revealed that students at SMP Negeri 2 Koba are permitted to use smartphones during lessons under regulated conditions. Brief interviews with 15 students from class VIII-A confirmed that all students own smartphones. However, to maintain classroom discipline, smartphones are collected by the homeroom teacher after each lesson and are only used during activities requiring them. This regulated access ensures that smartphone use is purposeful and supports the integration of RPG-based learning in a controlled environment.

Planning Phase

The planning phase builds on the findings from the analysis phase, providing a foundation for designing the initial product. During this stage, critical decisions were made regarding the integration of learning materials and gameplay into the game-based learning medium. The implementation of this medium at SMP Negeri 2 Koba is tailored to align with students' preference for visual learning, addressing the limitations

of current teaching methods that rely heavily on traditional lectures and textbooks, which lack interactivity and engagement. The role-playing game (RPG) genre was chosen due to its widespread popularity in Indonesia, making it a familiar and appealing format for students. RPGs offer a highly engaging medium that aligns with students' gaming preferences, ensuring effective integration into the learning process. Furthermore, the use of smartphones, permitted under regulated conditions at SMP Negeri 2 Koba, supports the incorporation of digital game-based learning into classroom activities. This accessibility ensures the practicality and feasibility of the approach, leveraging available technological resources to enhance the educational experience. By addressing these considerations, the planning phase ensures that the game-based learning medium is relevant, engaging, and aligned with curriculum objectives, providing a robust foundation for the subsequent development stages.

Game Development

The game development stage comprises several critical steps, including naming the game, designing the visual and narrative elements, creating in-game characters and items, and developing the prologue, dialogues, scripts, and storyboards. Additionally, this stage involves constructing the essential learning media components. The process is outlined as follows:

1. Selecting the name of the game to be developed. The RPG-based mathematics game developed in this study is named MATHGEO, designed to teach mathematical concepts through an engaging and interactive medium. The game includes six maps: five main maps and one prologue map, each integrated into a cohesive storyline. The narrative revolves around a quest to retrieve a valuable object for a king, providing players with a structured journey across various environments, including the main hall of the Snow Kingdom, the outer courtyard, the snow village, and two levels of a library. These maps are designed to encourage exploration and active engagement, supporting the educational objectives of the game. To facilitate simplicity and user-friendliness, the in-game currency is represented by gold, avoiding large numerical values and ensuring straightforward transactions. The game employs a sequential mission design, requiring players to complete each task before advancing to the next, thereby reinforcing a structured learning path.
2. Designning the background display. The background design for each section of the game is developed using a map editor, ensuring visually appealing and thematically consistent settings that align with the storyline and gameplay.
3. Designing Characters for the Game. The game includes the creation of both main characters and supporting characters. Main characters are designed to represent the players' avatars, allowing them to navigate the storyline and complete missions. These characters are intentionally crafted to be relatable and engaging, often reflecting the target audience's preferences and interests. Supporting characters, on the other hand, are designed to enrich the storyline, provide contextual information, and assist players in completing missions. These characters may include mentors, allies, or non-playable characters (NPCs) that serve as guides or obstacles in the game, ensuring an interactive and dynamic learning experience.
4. Creation of Other In-Game Items. In addition to characters, various in-game items are developed to enhance gameplay and support learning

objectives. These items include tools, treasures, or power-ups that players can acquire throughout the game to aid in completing missions. For instance, the use of mathematical tools such as rulers or protractors in the game aligns with the educational content and reinforces the application of mathematical concepts in problem-solving scenarios. Additionally, collectible items such as gold coins or keys provide rewards and incentives, encouraging players to engage deeply with the game while achieving learning outcomes.

5. Making Prologues, Dialogues, and Scripts. The prologue, dialogues, and scripts form the narrative backbone of the game, setting the stage for players' immersion in the storyline. The prologue introduces the plot and provides players with an overview of the game's objectives, creating an initial sense of purpose and excitement. Dialogues between characters, including interactions with supporting characters and NPCs, are carefully scripted to guide players through challenges, offer hints, or deliver educational content. Scripts also govern in-game events, such as transitions between maps or activation of missions, ensuring a seamless and engaging flow of activities.
6. Developing Learning Media Storyboards. Storyboards are a crucial component in the design process, serving as a visual blueprint for the game's structure and flow. Each storyboard outlines the sequence of events, including character movements, dialogue exchanges, and gameplay mechanics. For the learning media component, storyboards map out how mathematical problems are integrated into the game, ensuring alignment with educational objectives. This structured approach allows developers to visualize the interaction between gameplay and learning, optimizing the educational impact of the game.

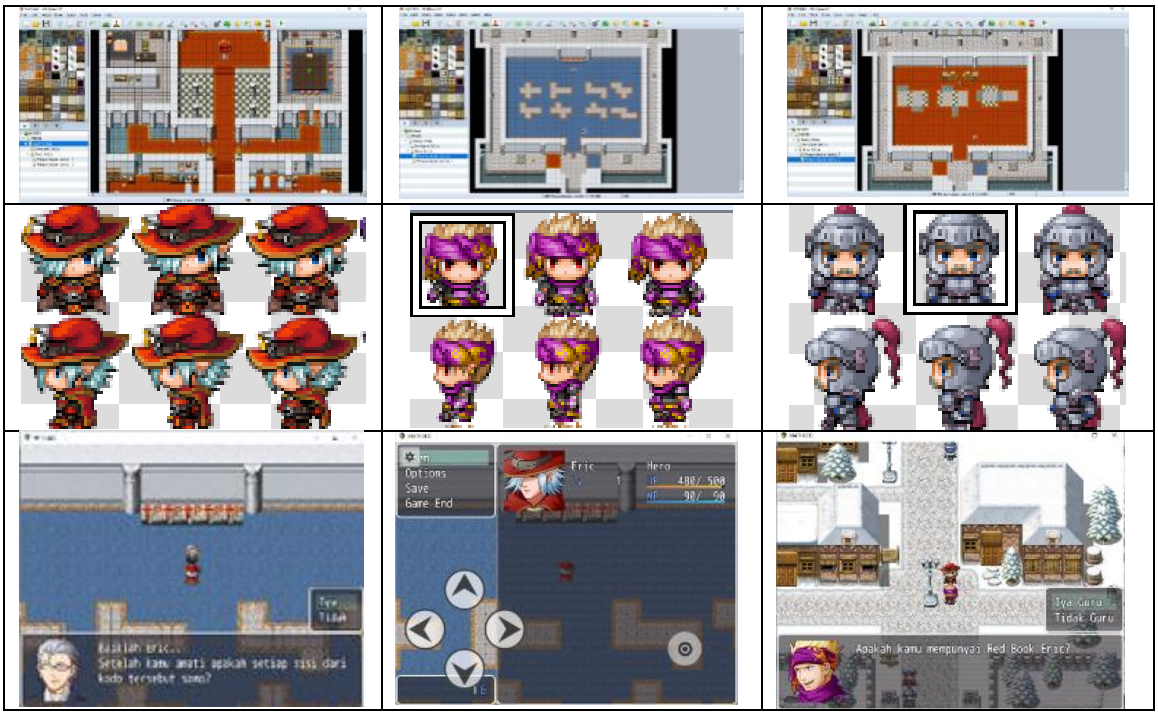

Figure 2. Game Development.

By addressing these aspects, the game development process ensures the creation of a comprehensive, engaging, and educational RPG-based learning tool that seamlessly integrates gameplay with mathematical learning objectives. This meticulous design approach not only enhances student interest but also promotes meaningful learning experiences.

Validation by Media Experts and Material Experts

The validation stage involves assessments by media and material experts to ensure the quality and effectiveness of the game-based learning media (Nieveen, 1999). Media experts evaluate the technical aspects, such as design, functionality, and user experience, while material experts assess the alignment of content with curriculum standards and its suitability for the target audience. Feedback from both experts is used to refine the game, addressing usability, content accuracy, and engagement. This process ensures the final product meets both pedagogical and technical standards, providing an effective and interactive learning tool for mathematics education.

Table 1. Media and Material Expert Validation.

No	Aspect	Average Score	Category
Media			
1	Technical quality	4.31	Very good
2	Instructional quality	4.71	Very good
	Overall average	**4.51**	**Very good**
Material			
1	Quality of content and purpose	4.90	Very good
2	Instructional quality	5.00	Very good
3	Technical quality	4.90	Very good
	Overall average	**4.93**	**Very good**

Revision

The revision stage focuses on refining the game-based learning media by incorporating feedback from media and material experts to enhance its technical and pedagogical quality. Key revisions include adding clear learning objectives within the game to help players understand their educational goals as they progress. Improvements were made to text elements by applying proper capitalization and formatting for better readability and professionalism. Additional instructions were incorporated to guide players effectively, ensuring smooth gameplay. Adjustments to character events were also implemented, allowing different scenarios to appear only after players successfully complete missions, thereby maintaining narrative flow and reinforcing task completion as part of the learning process. These revisions ensure that the game is engaging, user-friendly, and aligned with its educational objectives, creating a more impactful learning experience.

Media Testing

The media testing phase involved the implementation of the game-based learning media with 18 eighth-grade students from Junior High School 2 Koba. This stage aimed to evaluate the practicality and effectiveness of the media in a real classroom setting. Following the testing, a questionnaire was administered to collect feedback from the students regarding their experiences with the learning tool. The results of this questionnaire are presented in Table 10, providing quantitative insights into student perceptions of the media's usability and engagement.

In addition to the questionnaire results, qualitative observations during the learning process highlighted increased

student enthusiasm and active engagement. Students participated more actively, demonstrated through collaborative discussions with peers while using the game-based media. Moreover, the application of the media encouraged students to become more inquisitive, as reflected in their willingness to ask questions during the lessons. These findings indicate that the game-based learning media successfully fostered a more interactive and dynamic learning environment, emphasizing its potential as an effective educational tool for teaching mathematics.

Table 2. The Results of Questionnaire.

No	Aspect	Average Score	Category
1	Pleasure	3.71	Good
2	Interest	3.27	Good
3	Satisfaction	3.50	Good
4	Motivation	3.70	Good
5	Desire	3.50	Good
6	Curiosity	3.50	Good
	Overall average	**3.54**	**Good**

Implementation Phase

The implementation of the game-based learning media with 18 eighth-grade students at SMP Negeri 2 Koba focused on improving interest and achievement in mathematics. Students first received a brief explanation on cubes and blocks before using the media, which they interacted with until completing the game. Challenges emerged with a few students who struggled to progress due to not following instructions, underscoring the need for clear guidance. Despite these challenges, the game-based media significantly enhanced students' interest and learning outcomes. Questionnaire results showed increased interest, with a mean score of 3.54 ('good'). These findings align with studies by Liu et al. (2020), which demonstrated that game-based learning enhances motivation and interest, and Ma (2020), who reported that role-playing stimulates learning engagement. Sun et al. (2022) also highlighted how role-playing facilitates the effective use of learning resources and intrinsic motivation. Improved academic performance was further evidenced by post-test results exceeding the competency standard. Research by Toomey et al. (2020) and Kodotchigova (2002) similarly supports the positive impact of role-playing on learning outcomes. Overall, this study concludes that RPG-based learning media is an effective instructional tool for increasing student interest and achievement in mathematics.

CONCLUSION

Based on the findings, the development of game-based instructional tools for teaching mathematics, particularly on flat-sided geometric materials, follows a structured process comprising analysis, game development, validation, revision, media testing, and feasibility assessment, resulting in high-quality learning resources that enhance students' interest and academic achievement. Validation scores from media experts averaged 4.51, and material experts scored 4.93, both categorized as 'very good,' confirming the validity of the media. Usability feedback from students yielded a mean score of 3.54, indicating practicality, while post-test results showed an average score of 80, exceeding the minimum competency standard (KKM) of 77, with a classical completeness rate of 83.33%, demonstrating the media's effectiveness. The implementation process included a brief introduction to cubes and blocks,

followed by the use of the game media, which engaged students until task completion and revealed increased learning interest and improved academic outcomes. To further enhance mathematics learning and research, it is recommended that MathGeo be integrated into the mathematics curriculum to boost student engagement and outcomes, tested on a larger population for additional feedback, and improved in terms of aesthetic appeal to align with contemporary gaming standards for greater engagement.

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