**MathQuest : A PowerPoint-Based Problem-Based Learning Game for Mathematical Problem-Solving**

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| **Article Info** |  | **Abstract** |
| ***Article history:***  Received: Month XX, 20XX  Revised: Month XX, 20XX  Accepted: Month XX, 20XX  (Cambria 9) |  | **Background of study:** Despite the importance of mathematical problem-solving skills in academic and everyday contexts, many students struggle to master these skills due to the lack of engaging and effective instructional tools. Traditional teaching methods often fail to address these challenges, highlighting the need for innovative approaches that integrate interactive and motivating elements into the learning process.  **Aims and scope of paper:** This study aims to develop and validate a PowerPoint-based Problem-Based Learning (PBL) game, evaluate its practicality in classrooms, and assess its effectiveness in improving students' mathematical problem-solving skills and motivation.  **Methods:** Using the ADDIE model, this research involved 33 tenth-grade students selected through purposive sampling. Validation by two media experts, two content experts, and two language experts ensured high-quality game design.  **Result:** Expert validation results showed high scores for content (91%), media design (89%), and language clarity (92%), indicating strong validity. The game achieved a practicality score of 85% based on student usability feedback. Effectiveness was demonstrated through a significant improvement in students' mathematical problem-solving skills, with average test scores increasing from 65 to 85 after using the game. Additionally, 70% of students reported increased motivation and engagement in learning mathematics through this game.  **Conclusion:** The PBL-based PowerPoint game demonstrated strong validity, practicality, and effectiveness in addressing the needs of students and enhancing their mathematical skills. Key educational game elements identified include immediate feedback, question variety, and the ability to play in groups, making it a viable tool for classroom implementation. |
| ***Keywords:***  Game Based Learning  Instructional Design  Interactive Learning  PowerPoint Games  Problem Based Learning (PBL) |
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**INTRODUCTION**

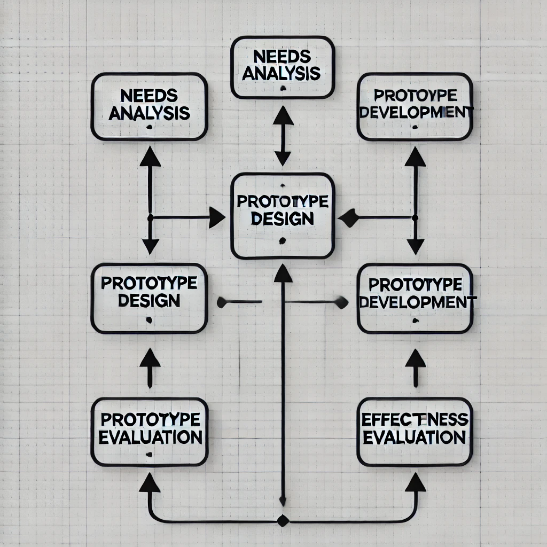
Mathematical problem-solving skills are essential competencies that students need to navigate academic challenges and everyday life effectively (Burke & Stewart, 2024). However, many students continue to struggle with developing these skills. Research indicates that a significant proportion of students face difficulties in solving mathematical problems (Nicolay et al., 2021), particularly in algebra, which is widely considered one of the most challenging topics ( Anugerah et al., 2024; Asri et al., 2024; Widyatma & Ramadhani , 2024 ; These challenges affect not only students' conceptual understanding but also their learning outcomes, critical thinking, and creativity (Sinaga et al., 2023; Subawo , 2022). Students with weak problem-solving skills often encounter obstacles in achieving optimal academic performance and struggle to apply concepts in real-world contexts (Tan et al., 2023).

In schools, traditional teaching methods such as lectures often fail to encourage students to think critically or engage actively in the learning process. Teachers also face challenges in explaining complex mathematical concepts and motivating students to learn (Ahmed & Mikail, 2022). Addressing these challenges requires innovative and relevant teaching approaches. One such approach is Problem-Based Learning (PBL), which has been proven to help students develop critical thinking and problem-solving skills (Erdem, 2022; Shongwe, 2024; Anggraeni et al., 2023a; Wei et al., 2023) . PBL emphasizes learning through real-world problem-solving, enabling students to better understand and apply their knowledge ( Marcinauskas et al., 2024; Serin, 2023). The integration of technology in PBL, including educational games, has been shown to enhance student motivation and engagement while making learning more effective (Hwang et al., 2019; Mao et al., 2021).

However, research on the use of technology in PBL often focuses on complex software or online platforms ( Anggraeni et al., 2023a; Hendarwati et al., 2021; Amin et al., 2021). Very few studies have explored the potential of PowerPoint as a simple yet effective platform for supporting PBL in mathematics education (Moradi & Noor, 2022; Rahman et al., 2020; Chang et al., 2020). Therefore, there is a need for comprehensive research that examines how PBL-based PowerPoint game designs can enhance students' mathematical problem-solving skills ( Anggraeni et al., 2023b). This study aims to develop and evaluate a PowerPoint-based PBL game as a solution to improve students' mathematical problem-solving skills. The game is designed by integrating PBL principles, instructional design theories, and gamification elements to create a learning experience that is effective, engaging, and accessible across various educational contexts.

**METHOD**

This study employs a research and development (R&D) method using the ADDIE model approach (Analysis, Design, Development, Implementation, Evaluation). This model was chosen for its systematic nature and suitability for developing technology-based learning media. The media developed in this study is a PowerPoint-based game called " MathQuest ", designed to enhance students' mathematical problem-solving skills. The stages of the research methodology are illustrated in the following flowchart:



**Figure 1.** Research Methodology Flowchart

The initial step in designing the game is conducting a needs analysis, which is a crucial phase in creating and developing an effective PBL-based PowerPoint game. This step provides an in-depth understanding of the specific challenges and needs faced by students and teachers in mathematics education. During this stage, data collection is carried out through surveys, which help identify the issues that need to be addressed and the features expected in the educational game. The results of the analysis will provide a solid foundation for creating a game that is not only relevant but also effective in enhancing students' mathematical problem-solving skills.

After identifying the needs and challenges through the needs analysis, the next step is the design and prototype development phase. This phase is a critical stage in creating a PBL-based PowerPoint game designed to address the identified needs. During the design stage, PBL principles and instructional design theories are integrated to ensure that the developed game is not only engaging but also educational and aligned with the learning objectives. Interactive elements and gamification are incorporated to enhance student engagement and facilitate deeper learning. The prototype development involves creating an initial version of the game that can be tested and evaluated. This prototype is designed to represent the agreed-upon features and content, including case-based mathematical challenges, interactive feedback, and relevant gamification elements.

After the prototype development is completed, the next stage is prototype validation to ensure the quality and effectiveness of the PBL-based PowerPoint game. Prototype validation is a crucial step in assessing the appropriateness of the content, media, and language used in the game. This process involves six experts: two content experts, two language experts, and two media experts. The content experts will evaluate the accuracy and relevance of the mathematical content, the language experts will ensure the clarity and appropriateness of the language used, and the media experts will assess the design and functionality of the media in the game. The goal of this validation process is to identify and address potential weaknesses before the game is tested with students, ensuring that the final product is not only engaging but also meets high educational standards. Interpretation of validation results is carried out using the following validity categories:

**Table 1.** Validity Category Interpretation

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| Score Range | Validity Category | Interpretation |
| 85% – 100% | Very Valid | Can be used without revision |
| 70% – 84% | Valid | Can be used with minor revisions |
| 50% – 69% | Less Valid | Requires major revisions |
| 0% – 49% | Not Valid | Not suitable for use |

In the evaluation stage, students' responses to the use of the PBL-based PowerPoint game in the mathematics learning process are measured. The focus of this evaluation is to gather direct feedback from students regarding their experience with the PowerPoint game and to assess the extent to which the game influences their perceptions and responses to the material being taught. This evaluation will involve 33 tenth-grade high school students. The instrument used at this stage is a student response questionnaire, designed to collect information about their experience with the PowerPoint game. Students will be asked to provide feedback on aspects such as engagement, ease of use, and the game's effect on their understanding of the material. The goal of this questionnaire is to assess the extent to which the PowerPoint game is accepted and perceived as beneficial by students in the context of their learning.

In this study, data analysis was conducted using descriptive statistical and qualitative analysis techniques in two main stages: expert validation and student response evaluation. For expert validation, the average scores for each aspect (language, content, and media) were calculated and interpreted using the validity category interpretation table (Table 1). Aspects with low scores were analyzed qualitatively to identify areas needing improvement, and revisions were made based on expert feedback to improve overall quality. For student responses, the average scores from the questionnaires were calculated to evaluate engagement, ease of use, and the game's impact on understanding mathematical concepts. These scores were also interpreted using the validity categories to assess the practicality and effectiveness of the game. Additionally, qualitative feedback from students was analyzed to gain deeper insights into their experiences and suggestions for improvement, providing a comprehensive evaluation of the media's validity, practicality, and effectiveness.

**RESULTS AND DISCUSSION**

The survey results conducted with 33 students revealed several key findings regarding their needs and expectations in mathematics learning. Refer to the following table:

**Table 2.** Results of student needs analysis for PBL-based Powerpoint Games

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| **Aspect** | **Percentage** | **Analysis results** |
| Difficulty in understanding mathematical materials | 75.8% | Most students had difficulty, indicating a need for more understandable and interactive materials. |
| The most difficult topic to understand is algebra | 57% | Algebra is the most difficult topic for students to understand, making it a priority for educational game development. Therefore, arithmetic sequences and series were chosen as a form of algebra application. |
| Interest in the use of games in learning | 87.9% | The majority of students are very interested in using games as a learning tool. |
| **Desired features in the game:** | |  |
| A variety of questions to choose from | 36.4% | Students want a variety of questions to broaden and deepen their understanding of the material. |
| Attractive graphics and visuals | 45.5% | Attractive graphics and visuals are important elements in creating an interesting learning experience. |
| Immediate feedback after each answer | 39.4% | Immediate feedback helps students correct mistakes and learn effectively. |
| Ability to play in groups | 51.5% | Group play features are a priority, demonstrating students' desire to learn collaboratively. |
| Satisfaction with current learning methods | 2.73 | Student satisfaction with current learning methods is low, indicating a need for improvement, especially in terms of interactivity. |

In addition, the survey conducted with six mathematics teachers provided insights into the challenges and needs in mathematics teaching. A summary of the survey results can be seen in Table 3.

**Table 3.** Results of Teacher Needs Analysis for PBL-Based PowerPoint Games

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| **Aspect** | **Percentage** | **Analysis Results** |
| Challenges in teaching mathematics | 83.4% | Most teachers face challenges, especially in explaining complex mathematical concepts and motivating students. |
| Belief in the use of educational games | 100% | All teachers agree that educational games can be a useful tool in teaching mathematics. |
| **Important features in educational games** | | |
| Ability to adjust difficulty level | 100% | Teachers want games that can adjust the difficulty level to suit students' needs. |
| Integration with curriculum | 100% | Integration with existing curriculum is essential to ensure game material is relevant to the lesson. |
| Features to monitor student progress | 100% | The reporting and monitoring features of student progress are considered very important by teachers. |
| Ability to provide feedback | 100% | Immediate feedback is considered a very important feature for student evaluation. |
| Perceptions of the effectiveness of current teaching methods | 50% | The scores indicate that although current teaching methods are considered quite effective, there is room for improvement, especially with the use of educational technology. |

The needs analysis of students and teachers indicates a significant demand for PBL-based PowerPoint games in mathematics education. Students expressed a desire for games that offer a variety of problems, interactive explanations, and immediate feedback to support their understanding. Recent studies by Sung et al. (2016) and Yu et al. (2022) emphasize the importance of integrating interactive elements and immediate feedback in educational games to enhance student engagement and comprehension. Meanwhile, teachers require games that can be aligned with the curriculum, provide student progress reports, and simplify the teaching of complex material. According to research by de-Marcos et al. (2014) and Bang et al. (2023) , the use of game technology in education allows teachers to monitor student progress in real-time and tailor instructional materials to individual needs. Developing games that meet these needs has the potential to improve students' problem-solving skills, increase student engagement, and enhance the overall effectiveness of mathematics instruction (Nadeem et al., 2023). Research by Hwang et al. (2019) also demonstrates that well-designed educational games, particularly those using a PBL approach, can significantly enhance students' problem-solving abilities.

After the needs analysis phase, the design and development of the PBL-based PowerPoint game prototype commenced. This prototype was designed to integrate the principles of Problem-Based Learning (PBL) and instructional design theory to create an engaging and effective learning tool. The game prototype features an attractive interface design, as shown in Figure 2, which displays the main screen of the game.

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**Figure 2.** Main view of powerpoint game

The main screen includes navigation buttons for selecting content. This design follows Sweller's Cognitive Load Theory (2024), which emphasizes the importance of reducing cognitive load through a simple and clear interface. The design concept also aligns with the principles of Universal Design for Learning (Roski et al., 2024), focusing on accessibility and inclusion in learning.

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| **Figure 3.** Example of a math challenge | **Figure 4.** Example of feedback in games |

Figure 3 illustrates an example of a case-based mathematics challenge within the game. This challenge is designed to stimulate problem-solving and the application of mathematical concepts. Each challenge is accompanied by interactive feedback, in line with Piaget's Constructivist Learning Theory ( Waite- Stupiansky , 2022 ), which emphasizes learning through direct experience and reflection. Research by Hernández-Ramos et al. (2021) also supports this approach, showing that problem-based learning environments can foster a deeper understanding of concepts.

This game prototype integrates key features such as case-based mathematics challenges, interactive feedback, and gamification elements. Research by Gholami et al. (2021) confirms that case-based learning enhances problem-solving skills by providing relevant context. The game provides immediate feedback after each response, helping students understand their mistakes and improve comprehension. This aligns with the formative assessment principles outlined by Haruna et al. (2021), which demonstrated that effective feedback can significantly improve learning outcomes. An example of the in-game feedback is shown in Figure 4.

The design and development of this PBL-based PowerPoint game prototype integrates various learning theories and instructional design principles to create a tool that is both engaging and educational. The intuitive interface design and gamification elements, as shown in Figures 3 and 4, are expected to enhance student engagement by making mathematics learning more appealing and relevant. Overall, the design and development phase of this prototype demonstrates that by integrating PBL principles and instructional design theory, the PBL-based PowerPoint game can offer an innovative and effective alternative for improving students' mathematical skills. Further evaluation of this prototype will determine the extent to which the game meets the identified needs.

After completing the design and development phase of the prototype, the next step is to conduct validation by experts to ensure the quality and suitability of the developed learning media. This validation is carried out by media experts, content experts, and language experts to evaluate the technical aspects, content, and language clarity of the PBL-based PowerPoint game. The results of this validation will provide insights into the feasibility of the game from various perspectives and serve as a basis for further improvements to better meet the identified learning needs. The validation results are presented in Figure 5.

**Figure 5.** Results of game validation by media and material experts

Based on the validation results conducted by content and media experts, it can be concluded that the PBL-based PowerPoint game demonstrates good validity as a learning medium. The aspects that contribute most to the validity score include the relevance and accuracy of the mathematical content, the clarity and appropriateness of the language used, and the interactive and visually engaging media design. These elements ensure that the game aligns with the learning objectives and effectively supports student engagement and understanding. The evaluation from the content expert validators indicates that the game effectively enhances students' understanding of the subject matter, aligns with the learning objectives, and successfully integrates the PBL approach. Suggestions for improvement include increasing the variety of questions and improving the responsiveness of interactive elements for further enhancement. Meanwhile, the assessment from media expert validators reveals that the visual design, technical quality, and innovation presented by the game are commendable. The game was rated as stable without technical issues, featuring an attractive and user-friendly interface for students. The recommendation to improve interactive responsiveness also reflects attention to detail that could enhance the user experience. Therefore, this game can be implemented in problem-based learning in schools, with a few suggested improvements to optimize students' learning experience.

Additionally, to ensure that the PBL-based PowerPoint game uses language that is clear, precise, and appropriate for the learning context, a validation was conducted by two language experts. This validation aims to assess the logic, readability, and accuracy of terminology used in the game, ensuring that the material is delivered effectively and is easily understood by students. The validation results from the two language experts regarding the linguistic aspects of the game can be seen in Figure 6.

The evaluation results indicate that the linguistic aspects of the game have met most of the expected criteria, although there are still some areas that could be improved. The clarity of the language used in the game is excellent and free from ambiguity. This aligns with the findings of Anggraini et al. (2022), who stated that clear and unambiguous language in educational media enhances the effectiveness of learning and improves students' comprehension of the material presented. Despite receiving a fairly good assessment, further review of certain text sections may be necessary to ensure that all students can easily grasp the messages conveyed in the game.

**Figure 6.** Game validation results by language experts

The alignment with the educational context has been adapted to the students' comprehension level. This is crucial, as Vygotsky (1978) emphasized that using language appropriate to students' cognitive development helps them construct meaning and deepen their understanding of concepts. Overly complex language can hinder students' ability to understand the material, while language that is too simple may not challenge them sufficiently.

The grammatical accuracy in the game is generally adequate, indicating that the grammar usage is largely correct, although there is room for minor improvements. This is important because correct grammar not only helps students better understand the material but also aids them in internalizing appropriate language use in academic contexts (Rahayu et al., 2024). Terminology consistency in the game shows that while the terms used are generally consistent, there are a few sections where the terminology could be further aligned. Consistency in terminology is a key element in educational media, as inconsistent use of terms can cause confusion among students ( bornka & Gani, 2024). The Alignment with learning objectives indicates that, overall, the game successfully delivers the learning content through language that supports students' comprehension. According to Bruner (1966), the language used in educational media should align with the learning objectives being pursued. On the aspect of readability, both validators gave positive assessments. Readability in educational media is crucial to ensure that students can access and comprehend the information without difficulty. Factors such as font size, color contrast, and text layout play important roles in determining readability (El Chidtian & Renzina , 2024).

In terms of creativity, both validators provided an adequate assessment. This suggests that the language used in the game is quite creative and engaging, although there is room for enhancing the appeal and innovation in language delivery. Creativity in language, particularly in game-based media, can boost student engagement and make learning more enjoyable (Lee, 2019). For the clarity of instructions, both validators gave high marks. Clear and easy-to-understand instructions are key factors in effective educational multimedia (Wei et al., 2018). Overall, the validation results from the two language experts indicate that the game has met most of the expected language standards for PBL-based educational media.

After the expert validation phase, the PBL-based PowerPoint game was tested with students to gather direct user feedback. This trial aimed to assess their perceptions of various aspects of the game, including design, ease of use, and the relevance of the learning material. The results of this survey will serve as a basis for evaluating student responses and providing input for further improvements.

Figure 7 indicates that the game successfully captured students' attention and actively engaged them in the learning process. Active student engagement is key to enhancing their understanding (Munna & Kalam, 2021), especially when students are given opportunities to participate in interactive and collaborative activities. This is further supported by 50% of students who felt that the game helped them collaborate with their peers, reinforcing the idea that social collaboration can improve conceptual understanding (Qureshi et al., 2023). In terms of material comprehension, 47% of students felt that the game helped them understand the material very well, while 39.4% rated it as good. The use of visual and interactive elements in the game can enhance students' understanding of complex concepts (Nurhikmah et al., 2023). Additionally, the application of concepts through gameplay received positive feedback from students, with 50% rating it as very good and 40% rating it as good. This suggests that the game not only aids in understanding theoretical concepts but also facilitates the application of these concepts in practical situations. The following is an overview of the student survey results regarding the tested game.

**Figure 7.** Student response survey results

In the aspect of Problem-Solving Skills Development, 65% of students rated the game as very good in training them to think critically when solving problems, while 60% indicated that the game encouraged them to think creatively in finding solutions. This supports previous research showing that problem-based games can enhance students' problem-solving skills by presenting scenarios that require critical and creative thinking ( O'Grady-Jones & Grant, 2023 ). The use of a PBL approach in this game helps students develop critical and creative thinking skills, which are essential competencies for the 21st century. Student motivation significantly increased after using the game, with 70% of students rating it very good in terms of boosting their interest in learning. According to ( Cho & Castañeda, 2019 ), students' intrinsic motivation increases when they engage in activities that are both engaging and enjoyable. Additionally, 65% of students reported feeling happy and not bored while learning with this game. This indicates that the PBL-based game successfully created an enjoyable learning environment, which in turn fostered higher learning motivation.

The visual aspect of the game received excellent ratings, with 75% of students stating that the visuals were engaging and supported learning. Additionally, 70% of students found the game easy to use and not confusing. Ease of use is crucial in technology-based learning, as technical difficulties can distract students from focusing on the material. Overall, the survey results indicate that this PBL-based PowerPoint game successfully enhanced student engagement, material comprehension, problem-solving skills, and learning motivation. These findings support previous research showing that interactive and engaging game-based learning can significantly improve the quality of education ( Videnovik et al., 2020). The use of games in learning not only makes students more active and motivated but also helps them develop critical and creative thinking skills, which are essential for facing future challenges.

The PowerPoint-based game " MathQuest " was specifically designed to enhance students' Problem-Based Learning (PBL) skills by integrating engaging, real-world mathematical problems into an interactive learning environment. The game presents scenarios requiring students to analyze, hypothesize, and solve challenges related to arithmetic and geometric sequences and series. For example, one level tasks students with planning the seating arrangement in a theater, requiring them to determine the total number of seats in rows that follow an arithmetic progression. Another level explores geometric series through a real-life scenario, such as calculating the total amount of water conserved in a multi-stage filtration system with diminishing returns. These problem contents simulate real-life situations, encouraging critical thinking and collaborative problem-solving. By providing immediate feedback, hints, and scaffolded problem progression, MathQuest supports students' engagement and fosters their ability to independently explore and resolve mathematical challenges. Research suggests that gamified environments like this can effectively motivate students and enhance their problem-solving skills by integrating active learning and collaboration (Hwang et al., 2019; Amin et al., 2021). The game's interactive elements, such as rewards for solving problems and penalties for incorrect attempts, encourage persistence and deepen understanding of mathematical concepts. This aligns with findings from PBL studies emphasizing the importance of engaging tasks in developing students' analytical and problem-solving skills ( Marcinauskas et al., 2024; Serin, 2023). As a result, MathQuest not only improves students' mastery of arithmetic and geometric sequences and series but also develops transferable PBL skills, preparing them for complex problem-solving in real-world contexts.

The limitations in the development of the PBL-based PowerPoint game include the constraints of PowerPoint in terms of interactivity and complex animations, as well as performance issues when excessive animations make the file heavy and unresponsive. Additionally, the game has limited capabilities for real-time feedback and automatic student progress tracking, as well as challenges in real-time collaboration and distribution across different devices. To address these limitations, it is recommended to use additional technologies such as VBA or macros to enhance interactivity, minimize excessive animations to keep the file lightweight, and integrate the game into online learning systems (LMS) or cloud-based platforms to facilitate collaboration and student progress tracking.

Despite these limitations, the contribution of this development research lies in demonstrating the potential of using PowerPoint, a widely accessible and easy-to-use tool, as a platform for creating interactive and educational games. This research provides a practical and cost-effective solution for integrating Problem-Based Learning (PBL) into classroom activities, particularly in contexts with limited access to advanced educational technologies. Furthermore, the development and validation processes outlined in this study offer a systematic framework that can be adapted by educators and researchers to design similar instructional media. By focusing on arithmetic and geometric sequences and series, this game serves as a concrete example of how abstract mathematical concepts can be transformed into engaging, real-world problem-solving scenarios, thus contributing to the improvement of students' mathematical problem-solving skills and fostering transferable PBL abilities.

**CONCLUSION**

The development of the PowerPoint-based Problem-Based Learning (PBL) game " MathQuest " demonstrates strong validity, practicality, and effectiveness as a learning medium for enhancing students' mathematical problem-solving skills and motivation. Validation results from experts showed high scores in content (91%), media design (89%), and language clarity (92%), indicating that the game is "very valid" and suitable for use without significant revisions. Feedback from 33 tenth-grade students provided a practicality score of 85%, reflecting the game's ease of use, engagement, and integration into classroom activities. Additionally, 70% of students reported increased motivation and engagement during the learning process.

This study highlights the potential of using a widely accessible tool like PowerPoint to create innovative and effective educational games. The integration of interactive elements, real-world problem-solving scenarios, and gamification ensures that the game is both engaging and educational. Key features, such as immediate feedback, a variety of problem types, and group play options, further enhance its practicality and applicability. MathQuest offers a viable alternative for improving students' mathematical skills while fostering Problem-Based Learning abilities, making it a valuable tool for classroom implementation. Future research is encouraged to explore the game's application to other mathematical topics and improve its interactivity by integrating it with online learning systems or cloud-based platforms.

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**AUTHOR CONTRIBUTIONS STATEMENT**

RS, NM, and IS contributed to the conception and design of the study. RS performed the data collection and analysis, while NM and IS provided input on the methodology and contributed to the interpretation of the results. GD was responsible for the linguistic review and proofreading of the manuscript. All authors read and approved the final version of the manuscript.

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