

Revolutionising Mathematics: Innovative Teaching Methods with ENJOYMATHS

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ABSTRACT

Mathematics is a critical core subject in primary and secondary schools, as well as in higher educational institutions. However, students are increasingly losing interest in this subject due to difficulties in understanding its concepts. An effective approach must be implemented to address this challenge. This study aims to investigate students' perceptions of an online learning game, ENJOYMATHS, as well as the associated influencing factors and the game's impact on them. A descriptive and logistic regression analysis was conducted to achieve the study's objectives. A total of 37 secondary school students and 40 diploma students participated in this research. The results indicate that most students have a favourable perception of ENJOYMATHS, with 97.4% enjoying the game and agreeing that it is easily accessible and convenient to play anywhere. Moreover, ENJOYMATHS has had a significant impact on students' interest in Mathematics, with 89.6% reporting increased enthusiasm for the subject and 93.5% finding it easier to understand mathematical topics such as fractions, percentages, and decimals. Additionally, 85% of the participants stated that the game enabled them to learn Mathematics independently at home. Furthermore, ENJOYMATHS shows promising market potential, as 57% of the students expressed interest in purchasing this interactive game application. The key factors influencing students' enjoyment of ENJOYMATHS are their Mathematics scores and the game's engaging and easy-to-understand design. In conclusion, ENJOYMATHS has a positive impact on students by helping them overcome difficulties in understanding fundamental mathematical concepts. It is hoped that this innovative teaching method will emerge as a transformative approach in future education.

1. INTRODUCTION

According to the Organisation for Economic Co-operation and Development [OECD] (2023), Malaysia has shown a declining trend in the average mathematics score, with a 31-point drop compared to the 2018 data. Unfortunately, this decline is also evident in other subjects, such as science and reading (OECD, 2023). This poor performance can largely be attributed to the impact of the pandemic that hit Malaysia in 2020. It is imperative for us to address these issues promptly to prevent further deterioration. A study by Manalu and Judijanto (2024) stated that the decline began five years ago, primarily due to students' inadequate

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grasp of core concepts. Additionally, Syaza et al. (2014) found that the poor performance is largely due to a lack of motivation in learning mathematics, suggesting that efforts to improve motivation should be prioritised. The importance of motivation in academic success was clearly explained by Mohamad (2019), who noted that individuals with high motivation possess a strong desire and determination to achieve their goals, pushing them to put in their best effort to succeed.

Interestingly, a study by Wahyuni et al. (2023) found that educational games provide many benefits in the teaching and learning process, including increasing student motivation and engagement. These educational games make learning more enjoyable and captivating, thereby encouraging students to engage more actively in their studies, leading to more effective and efficient learning outcomes. Furthermore, such games promote interactivity and active participation, enabling students to directly engage in the learning process. As a result, educational games can help students develop a better understanding of the material and improve their overall academic performance.

Based on these findings, a mathematics game module called "ENJOYMATHS" was created to increase student motivation and improve performance in mathematics, ensuring effective and efficient learning. The ENJOYMATHS tool addresses the issue of poor mathematics performance by focusing on strengthening basic mathematics skills, such as addition, subtraction, multiplication, and division. It combines both physical (card) games and digital games to help students become proficient in basic skills, particularly in multiplication. The tool eliminates the need for students to memorise multiplication rules conventionally, which can be tedious and demotivating. Instead, students can naturally internalise these rules while enjoying interactive learning through the game. This approach helps students retain essential skills in a fun and engaging manner.

Educational games have been proven to be effective in learning because they make the learning process enjoyable. They also improve communication skills, decision-making, and teamwork, all of which help boost motivation and, ultimately, improve mathematics performance (García-López et al., 2023; Videnovik et al., 2023).

The ENJOYMATHS game has been on the market for almost six years, available in both digital online and tangible formats. It has attracted a following among school students. Therefore, this study seeks to explore students' perceptions of ENJOYMATHS, the factors that shape their opinions, and how it affects their learning.

2. LITERATURE REVIEW

The advent of the Fourth Industrial Revolution (4IR) has precipitated a paradigm shift in pedagogical approaches, particularly within mathematics education, necessitating innovative strategies such as online mathematics games to cultivate an autonomous, active, and collaborative learning environment (Marange & Adendorff, 2021). This evolution is largely driven by the potential of gamified learning environments to enhance student engagement and improve academic performance through the integration of game mechanics and interactive technologies into digital platforms (Pereira et al., 2024). This approach, often referred to as Gamified Mathematics Education, leverages elements such as points, badges, levels, and leaderboards to foster motivation and enhance deeper cognitive engagement among learners (Adenike et al., 2024). This integration significantly enhances the learning experience by making it more enjoyable and interactive, thereby promoting active participation, problem-solving, and critical thinking skills among students (Asogwa et al., 2023).

This is particularly relevant in the post-COVID era, where digital learning platforms have become indispensable, and game-based learning has been identified as a highly effective instructional method across various academic subjects, including mathematics, especially for Generation Z (Hidayat et al., 2024). This pedagogical shift toward game-based learning in mathematics involves using pre-existing games, incorporating gamified elements into conventional learning activities, or creating bespoke educational games tailored to specific learning outcomes (Hidayat et al., 2024). These methods consistently increase student motivation and engagement, thereby facilitating improved cognitive development and deeper

learning within mathematical domains (Pereira et al., 2024). By creating interactive and participatory learning environments, such approaches move beyond traditional one-way communication models and foster heightened student engagement (AlAli & Wardat, 2024).

Indeed, gamification, defined as the application of game-design elements and game principles in non-game contexts, has been demonstrably effective in augmenting student motivation and academic achievement by transforming educational content into engaging experiences (Meylani, 2025; Pereira et al., 2024). This strategy is further supported by educational psychology, specifically Self-Determination Theory, which posits that individuals are driven by their innate needs for autonomy, competence, and relatedness, all of which can be addressed through well-designed gamified experiences (Maryana et al., 2024; Meylani, 2025).

The urgency of integrating these gamified platforms is further underscored by the pronounced decline in global mathematical competency observed in the wake of the COVID-19 pandemic. Remote learning constraints led to significant instructional disruptions, resulting in acute learning losses particularly evident in foundational mathematical skills (Asogwa et al., 2023). Bespoke interventions like ENJOYMATHS are therefore critical to bridging these contemporary competency gaps by offering adaptive, self-paced remediation that re-engages students outside traditional classroom boundaries.

3. METHODOLOGY

ENJOYMATHS is an enhanced matching game specifically designed to explore inequalities and basic operations in fractions, percentages, and decimals. It integrates both physical card games (Figure 1) and digital games (Figure 2). Designed for young learners, ENJOYMATHS utilises engaging visual aids and interactive activities to simplify fundamental fraction concepts. The game consists of three phases: similarities, inequalities, and addition, each with five interactive stages aimed at capturing users' interest. With a user-friendly interface optimised for both mobile devices and websites, the game ensures accessibility across multiple platforms, making learning more flexible. Clear and simple instructions help guide children through the gameplay, which involves matching and comparing fractions, percentages, and decimals. The game adapts to individual learning speeds by adjusting difficulty levels accordingly. Students can access the game anytime, from anywhere, allowing them to practise at their own pace. The platform also provides valuable insights for parents and teachers to track progress and identify areas that may require extra support. Featuring high-quality graphics, smooth performance, animations explaining fraction concepts, sound effects, and music, the game enhances user experience, keeping students motivated and engaged throughout their learning journey.

3.1 Data Analysis

This study is a cross-sectional analysis of data collected from a subset of 37 school students and 40 diploma students at a specific time point. The study consisted of three main stages: literature review, survey question development, and data collection. The study began with a thorough literature review. Following this, a detailed survey questionnaire was created with four sections. The first section covers demographic factors, such as gender, age and Mathematics scores. The subsequent sections include multiple-choice questions about student's interest in ENJOYMATHS with three response options (Yes, No, and Not Sure). There are four questions in this section: (1) I really love playing ENJOYMATHS GAME, (2) I love playing ENJOYMATHS game as I can play and learn anywhere, (3) I love playing ENJOYMATHS game because it is straightforward and interesting, and (4) My interest in the Mathematics subject has increased after playing ENJOYMATHS game.

The third section comprises two multiple-choice questions with three response options (Yes, No and Not Sure) regarding participants' perceptions on ENJOYMATHS, such as (1) I can understand the concepts of fractions, percentages, and decimals easily after playing ENJOYMATHS game, and (2) I can learn Mathematics by myself at home by playing ENJOYMATHS game. The last section focuses on participants' acceptance of ENJOYMATHS with two multiple-choice questions with three response options (Yes, No

and Not Sure) and one open-ended question. The first two questions are: (1) I will recommend ENJOYMATHS to friends and family and (2) I am interested in purchasing the ENJOYMATHS game application. The third question is an open-ended question: (1) Are you willing to purchase the ENJOYMATHS game application and at what price?

Data collection was carried out immediately after distributing the survey questions using a simple random sampling technique. All collected data was then recorded and analysed using open-source software R. The data was screened, explored, and cleaned. Distributions and frequencies were examined, and descriptive analysis was conducted. Data exploration included creating graphs for each variable. Additionally, a logistic regression analysis was conducted to identify the factors influencing a student's decision to choose ENJOYMATHS, represented by a binary indicator variable where 0 indicates 'No' and 1 indicates 'Yes' for each subject as either a 'success' or 'failure'. The probability of success, denoted as $\pi(x)$, represents the likelihood of success at a given value of x . Therefore, the logistic regression model takes the form of a linear relationship for the logit of this probability,

$$\text{logit}[\pi(x)] = \log [(\pi(x)) / (1 - \pi(x))] = \alpha + \beta x. \quad (1)$$



Fig. 1. Physical Games

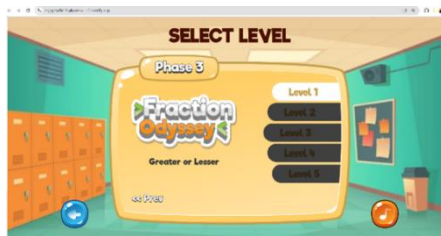


Fig. 2. Online Games

The automatic stepwise selection method was applied for variable selection, incorporating both forward and backward stepwise procedures. Additionally, interactions between pairs of variables from the main effects model were examined. At this point, a preliminary final model was developed. Further analysis

was then carried out to verify the accuracy and predictive validity of the logistic regression model. The variables from the three sections are listed and labelled in the logistic regression as follows:

- Y: Enjoy playing ENJOYMATHS
- X₁: Gender
- X₂: Age
- X₃: Mathematics score
- X₄: ENJOYMATHS can be played anywhere
- X₅: ENJOYMATHS is straightforward and engaging
- X₆: ENJOYMATHS increases interest in mathematics
- X₇: ENJOYMATHS helps understanding mathematics
- X₈: I can study alone using ENJOYMATHS
- X₉: I would recommend ENJOYMATHS to others
- X₁₀: I am interested in purchasing ENJOYMATHS

4. FINDINGS & DISCUSSION

This section is divided into two parts, (1) data exploration and (2) logistic regression model. The data exploration section presents descriptive statistics on demographic characteristics, students' interests, perceptions, and acceptance of ENJOYMATHS. Meanwhile, the logistic regression model section outlines the logistic model and identifies the factors that influence students' acceptance of ENJOYMATHS.

4.1 Data Exploration

Descriptive statistics were conducted using summary tables for quantitative variables and pie charts and bar plots for qualitative variables. Table 1 summarises the numerical data for two variables: age and the purchasing price of the ENJOYMATHS game. The quantitative variables were assessed based on six values: range, minimum, maximum, mean, standard deviation, and variance. The age range of the respondents in Table 1 is from 10 to 28 years old, suggesting that the ENJOYMATHS game is suitable for a diverse range of ages. The minimum mathematics score is 0, and the maximum score is 100, with an average score of 72. This demonstrates that the ENJOYMATHS game can benefit not only struggling students but also high-achieving ones. In terms of purchasing price, some respondents preferred to receive the ENJOYMATHS game for free, while others were willing to pay up to RM20. The average purchasing price is approximately RM4.37.

Table 1. Summary of Numerical Variables

Summary Statistics	Age	Mathematics Score	Purchasing Price
Range	18.00	100.00	20.00
Minimum	10.00	0.00	0.00
Maximum	28.00	100.00	20.00
Mean	17.40	72.17	4.37
Standard Deviation	3.16	25.66	3.78
Variance	10.03	658.38	14.32

Figure 3 illustrates the demographic characteristics of the respondents. Figure 3(a) shows that a total of 77 students participated in the study, with 33 males and 44 females. Figure 3(b), 14 students failed in mathematics, while the remaining respondents passed. The majority of the respondents are 20 years old, with 54 students in this age group, followed by 15-year-olds (18 students) and 14-year-olds (12 students). The other age groups have only 1 or 2 students, as depicted in Figure 3(c).

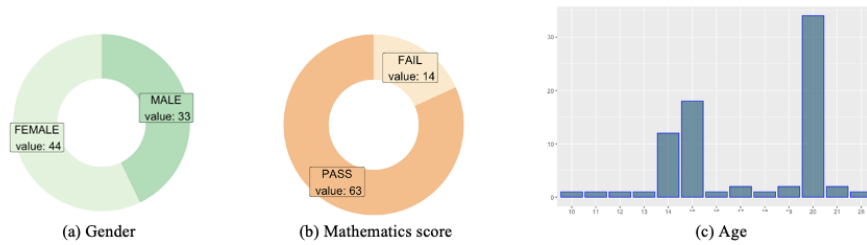


Fig. 3. Demographic Characteristics

Figure 4 presents students' interest in the ENJOYMATHS game. Both Figure 4(a) and Figure 4(b) indicate that most respondents (75 students, or 97.4%) found the game enjoyable and accessible. Additionally, Figure 4(c) shows that 94.8% of the students love playing ENJOYMATHS due to its simplicity and engaging nature. Figure 4(d) demonstrates that 89.6% of the students reported an increase in their interest in mathematics after playing the ENJOYMATHS game.

According to Hui and Mahmud (2023), game-based learning makes learning mathematics more interesting because games incorporate elements of entertainment. This approach transforms the learning experience into a fun and exciting activity, encouraging students to participate with enthusiasm and passion. Rosni et al. (2024) further support this view, noting that students who enjoyed learning mathematics through game-based interventions achieved the highest scores in their study. Orim et al. (2011) provide further detail on why games appeal to students in mathematics learning: they boost motivation by fostering a sense of competition, reduce anxiety associated with the subject, and enhance understanding of mathematical concepts. These findings highlight the importance of making mathematics learning engaging, and academicians should prioritise this aspect to foster motivation and ultimately improve students' academic performance. The ENJOYMATHS platform is therefore valuable for educators and students alike, as it helps overcome fear and anxiety in learning mathematics while increasing enjoyment and motivation among students.

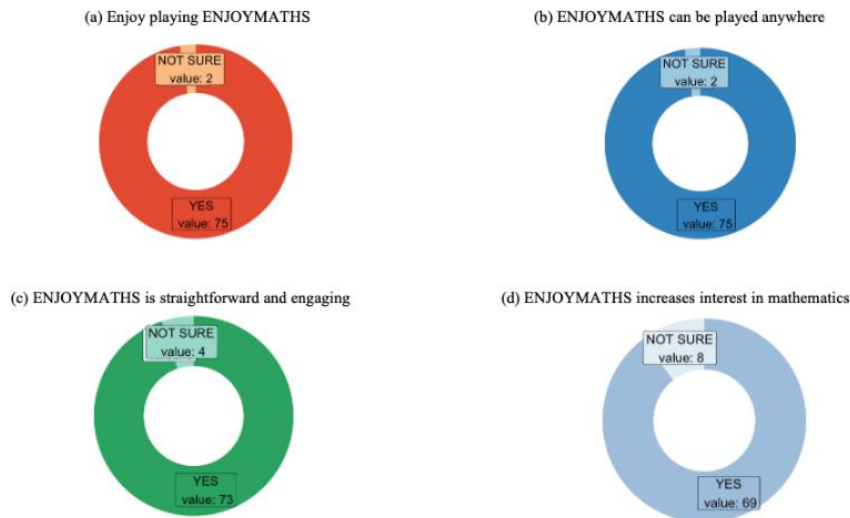


Fig. 4. Student's Interest

Figure 5 shows the students' perception of ENJOYMATHS. Figure 5(a) depicts that 93.5% of the students found it easier to understand mathematical topics such as fractions, percentages, and decimals. Figure 5(b) shows that 85% of the students can now learn mathematics independently at home with the help of ENJOYMATHS. Research indicates that mathematical games, whether digital or tangible, augment engagement and interest in mathematics. A study conducted by Li et al. (2020) in a Shanghai primary school found that daily gameplay markedly enhanced student motivation. Digital games have been shown to enhance performance, as evidenced by a survey of 397 students that reported positive feedback from both students and educators, resulting in improved post-test outcomes (Catarina & Fátima, 2023). Students frequently perceive mathematical games as entertaining and satisfying, which motivates them to use them for educational purposes (Guerra & Díaz, 2018). These games also enhance focus and problem-solving skills by prompting students to conceptualise mathematics innovatively and apply their skills to multiple problems (Lori, 2006). James et al. (2023) indicate that mathematical games are captivating and engaging, frequently fostering debates and collaboration. Meanwhile, Qing et al. (2016) proved that mathematics games provide valuable experiences and enhance learning by offering creativity and new insights into mathematical ideas.

Figure 6 illustrates students' acceptance of the ENJOYMATHS game. In Figure 6(a), 80.5% of students would recommend the game to their friends and family. Figure 6(b) indicates that ENJOYMATHS has a strong potential for a broader market, as 57% of students expressed interest in purchasing this interactive game application. The high levels of student acceptance and willingness to recommend and purchase the ENJOYMATHS game, as depicted in Figure 6, are consistent with existing literature on the effectiveness of educational games in enhancing mathematics learning.

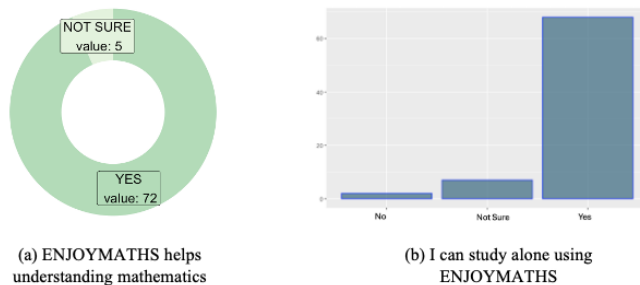


Fig. 5. Student's Perception

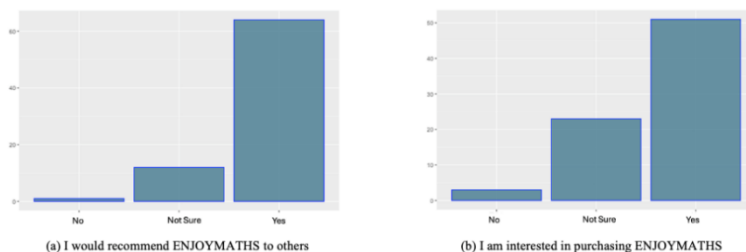


Fig. 6. Student's Acceptance

The idea of "edutainment," which blends education with entertainment, has gained popularity among parents seeking engaging learning options for their children. By incorporating interactive elements, this approach makes learning more enjoyable, enhancing both the perceived value and commercial appeal of educational games (Tapp, 2025). Ibrahim et al. (2017) explored the factors affecting students' acceptance

of educational games in higher education and found that enjoyment and perceived usefulness played a key role in their willingness to use and recommend these games.

Recent research has examined the willingness of students and parents to invest in online educational games. Kaur et al. (2021) conducted a study on university students in Sarawak, Malaysia, specifically focusing on in-app purchasing behaviours in online games. Their findings showed that 91% of the 100 students surveyed had made in-app purchases, demonstrating a strong tendency among students to spend money on digital gaming content. Meanwhile, Chen et al. (2021) investigated parents' readiness to pay for online learning platforms for middle school students in China. Their research revealed that parents' perceived value of online education significantly influenced their investment decisions. Additional factors such as social influence and online reviews also contributed to their purchasing choices.

Xie et al. (2021) studied the perspectives of students, parents, and teachers on digital educational games. Their results indicated that students held more favourable opinions compared to parents and teachers. Interestingly, after being introduced to an educational digital game, both students and parents showed an increased willingness to recommend game-based learning, suggesting a rising acceptance of investing in such resources.

Together, these studies highlight an increasing interest in online educational games among students and parents, driven by perceived value, social influence, and prior exposure to digital gaming. In conclusion, the positive feedback on the ENJOYMATHS game aligns with existing research showing that well-designed educational games can boost student engagement and learning in mathematics. To further enhance adoption and market potential, it is crucial to develop games that align with educational goals and student preferences.

4.2 Logistic Regression Model

This section discusses the logistic regression results for the factors that influence students' love and enjoyment of playing ENJOYMATHS. To establish the final model, a multi-variate analysis was initially performed utilising all ten collected parameters (X_1 through X_{10}), providing a comprehensive view of demographic, perceptual, and behavioral factors. The parameter coefficients were estimated using the maximum likelihood estimation method. An automatic stepwise selection framework, executing alternating forward and backward procedures, was utilised to isolate the most parsimonious model based on minimising the Akaike Information Criterion (AIC). Through this iterative process, eight variables including Gender (X_1), Age (X_2), App portability (X_4), Increased Interest (X_6), Conceptual Understanding (X_7), Independent Study (X_8), Willingness to Recommend (X_9) and Purchase Intention (X_{10}), were excluded from the final mathematical expression. While descriptive data shows high baseline appreciation for attributes like app portability (97.4%), the stepwise regression determined that these excluded elements did not contribute unique statistical significance when pitted against the primary drivers. This reveals that while secondary features support user experience, a student's existing baseline Mathematics score (X_3) and game's engaging and straightforward nature (X_5) serve as the definitive, independent catalysts behind their genuine enjoyment of the platform. The estimated logistic model is as follows:

$$\log \left[\frac{\hat{\pi}(x)}{1 - \hat{\pi}(x)} \right] = 67.225 - 1.923X_3 + 149.690X_5. \quad (2)$$

Table 2 shows the coefficient values for all predictor variables related to multicollinearity. The factors influencing students' enjoyment of ENJOYMATHS are their Mathematics scores (X_3) and the game's engaging and straightforward nature (X_5). The Variance Inflation Factor (VIF) value for the quantitative variable (Mathematics score) indicates no significant multicollinearity, as the value is less than 10. Additionally, the correlation between the two factors shows a weak positive relationship, suggesting no serious multicollinearity. Based on the exp (B) values, the following conclusions can be made:

- I. A one-unit increase in Mathematics score is associated with a 14.6% increase in the probability of students enjoying ENJOYMATHS.

- II. The probability of students enjoying ENJOYMATHS significantly increases by 1.022×10^{65} times when the game is more straightforward and engaging.

Table 2. Coefficient of Predictor Variables in Regression Model

Variables	B ^a	Exp(B) ^b	Multicollinearity
X ₃ (Mathematics score)	-1.923	1.461e-01	0.839 ^c
X ₅ (Straightforward and engaging)	149.690	1.022e+65	0.324 ^d

^aValue of coefficient ^bExponential value of coefficient

These results indicate that students with higher mathematics scores are more likely to enjoy playing ENJOYMATHS. Students are generally drawn to online games that are straightforward, easy to play, and engaging. This is supported by Videnovik et al. (2023), who stated that game-based learning in computer science education can enhance student understanding and knowledge retention, particularly when instructional games are aligned with curriculum objectives. However, the effectiveness of gamification depends on factors like curriculum design, instructional design practices, game design quality, curriculum integration, and student demographics (Zhan et al., 2022). Similarly, García-López et al. (2023) argued that the combination of gamification elements such as leaderboards, badges, and points systems can create a dynamic learning environment that encourages students to engage more actively.

5. CONCLUSION

Teachers play a crucial role in creating a supportive learning environment that fosters self-confidence and critical thinking skills. Students develop confidence when they receive proper instruction and guidance from their teachers. At the same time, school administrators must support and actively participate in planning school programs that positively impact students' success in mathematics.

This study revealed that students are actively engaged in the activities, sparking their interest in learning mathematics. It not only increases students' enthusiasm for the subject but also promotes positive behavioural changes and indirectly enhances their academic performance. ENJOYMATHS has demonstrated remarkable potential in enhancing students' understanding and interaction with fundamental fraction concepts. By integrating innovative game-based learning with interactive online engagement, this educational tool effectively addresses common challenges students face in mastering fractions.

To maximise the benefits of ENJOYMATHS, educational institutions and schools are encouraged to incorporate the game into their mathematics curriculum. Effective implementation should involve active participation from teachers and parents to support learning at home. Further research is needed to evaluate the game's long-term impact on diverse student groups, while expanding its scope to include other fundamental mathematical concepts for improved overall proficiency. Moreover, educational policymakers should advocate for the integration of game-based learning tools into national education strategies, fostering the use of innovative technologies to enhance mathematics education and boost academic success.

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7. CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests with the funders.

8. AUTHORS' CONTRIBUTIONS

Nazirah Ramli: contributed to the conceptualisation and overall supervision of the study. **Siti Rosiah Mohamed:** led the manuscript writing, data analysis, and coordination of the research process. **Norlaila Mohd Din** and **Ainun Hafizah Mohd:** assisted in literature review and data validation. **Noor Izyan Mohamad Adnan:** contributed to statistical analysis and interpretation of findings. All authors read and approved the final version of the manuscript.

9. DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES

This manuscript was developed with the assistance of Gemini for the purpose of improving the clarity, grammar, and overall readability of the text. The tool/service supported the author(s) in reviewing and refining the content, and the authors assume full responsibility for the final version submitted for publication.

11. DATA AVAILABILITY/SUPPLEMENTARY MATERIALS

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

12. ETHICS STATEMENT

Informed consent was obtained from all participants, and data anonymity was strictly maintained throughout the study.

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