Game-Based Learning Innovation in Mathematics: Evaluating Student Experiences with Trigonometric PowerPoint Games

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Received: 19 January 2026
Received in revised form: 16 February 2026
Accepted: 2 March 2026
Published: 10 March 2026

ABSTRACT

This study evaluates an innovative PowerPoint game targeting basic trigonometric identities and angle-finding skills to improve students' learning engagement. Traditional trigonometric instruction presents significant challenges, with students struggling to connect abstract concepts to practical applications and master fundamental identity relationships. To address these learning difficulties, we developed an accessible game-based solution using PowerPoint, incorporating interactive identity verification exercises, visual angle measurement activities, and immediate feedback mechanisms for enhanced accuracy. A descriptive statistical approach assessed 35 diploma students' feedback and performance using a 12-item Likert scale. All items scored above 4.3 on a 5-point Likert scale, indicating strong favourable reactions. Students strongly agreed that the game helped them recognize and fix mistakes (Mean = 4.68, SD = 0.57) and kept them actively interested in the class (Mean = 4.55, SD = 0.60), demonstrating effective engagement and reflective learning promotion. High scores were observed for enjoyment, retention, and problem-solving capabilities. Items related to peer collaboration and game adaptability received slightly lower scores, suggesting enhancement opportunities for future iterations. The PowerPoint-based interface made abstract trigonometric ideas interactive, with students reporting enhanced confidence in identity manipulation and angle measuring procedures, providing useful insights for mathematics education innovation while maintaining practical classroom implementation feasibility.

Keywords
Trigonometry education; Educational games; PowerPoint games; Gamification; Teaching innovation; Student engagement

Introduction

Trigonometry is a foundational topic in mathematics that plays critical role in science, technology, engineering and mathematics (STEM) education. Despite its importance, trigonometry is widely recognized as one of the most challenging domains in mathematics at secondary and higher levels of education (Orhani, 2024). Students frequently struggle with abstract representations, symbolic manipulation and the application of trigonometric identities and angle relationships in problem-solving contexts (Orhani, 2024; Rohimah & Prabawanto, 2020). These difficulties often result in low confidence, persistent misconceptions and reduced motivation to engage with the subject matter (Dhugana et al., 2023; Hidayati, 2020).

Traditional teaching methods, while foundational, frequently fail to adequately address diverse learning styles and maintain student engagement throughout complex trigonometric concepts (Mosia & Egara, 2024). As a results, students who were taught using conventional methods frequently exhibit low motivation and difficulty in transferring trigonometric knowledge to problem-solving contexts, particularly when dealing with identities and angle-related tasks (Canonigo, 2025; Mosia & Egara, 2024; Fererde et al., 2024). These limitations highlight the need for alternative pedagogical strategies that can support conceptual understanding while fostering active engagement.

In response to these challenges, the integration of game-based learning has emerged as a promising pedagogical approach in mathematics education. Previous research demonstrated that game-based learning can significantly

e-ISSN 2600-8572 | DOI: https://doi.org/10.11113/itlj.v10.227

enhance student engagement, motivation and academic performance by incorporating elements such as interactivity, challenge, feedback and structured progression (Meylani, 2025; Soboleva et al., 2021). Educational games have also been shown to reduce learning anxiety and promote intrinsic motivation through gamification features such as points, rewards and achievement systems (Ramli et al., 2020). Empirical studies report improvement rates of between 80% and 95% in learning outcomes when educational games are appropriately designed and implemented, particularly for abstract mathematical concepts that benefit from visual and interactive representations (Debrenti, 2024).

Research in Malaysia has shown that digital game-based learning significantly affects student achievements in mathematics, with studies conducted at institutions like SMK Kompleks Gong Badak demonstrating positive correlations between gaming approaches and academic performance (Mansor & Rosly, 2024). Other study conducted by Salsabila et al., 2020 indicated that 93.75% of educators agree with using digital educational games in mathematics education able to increase student's interest and reduce learning anxiety. Yong et al., 2019 reported that 175 secondary students' attitudes while learning mathematics were significantly influenced by their interest in mathematics, types of games played and gameplay duration. These findings align with global trends emphasizing the need for innovative pedagogical approaches that can bridge conventional teaching methods with contemporary learning preferences.

Trigonometry presents unique pedagogical challenges due to its abstract nature and the complexity of spatial-temporal relationships inherent in trigonometric functions (Weng, 2022). Traditional instructional approaches often result in fragmented understanding, with students struggling to connect theoretical concepts to practical applications (Abdullah & Yunianta, 2018). Game-based learning has been identified as particularly effective for trigonometry education, as it supports interactive visualisation and experiential learning. Studies focusing specifically on trigonometry have demonstrated significant learning improvements through role-playing game elements, web-based trigonometry games, and digital learning environments that encourage self-directed learning and active engagement (Masum et al., 2018; Weng, 2022). Malaysian research conducted at Universiti Sains Islam Malaysia further supports this view, showing that gamification combined with structured note-taking and diverse game formats can enhance learning in Additional Mathematics topics closely related to trigonometry (Anuar et al., 2024).

Despite the growing research on digital games in mathematics education, many existing game-based solutions rely on specialized software, advanced programming skills or high technological infrastructure. Such requirements can limit adoption, particularly in contexts where resources, technical support or teacher training are constrained. Consequently, there is a growing need for accessible and low-cost game-based learning tools such as PowerPoint that can function as a gamified learning platform, especially in learning trigonometry (Iliyas & Jumaat, 2020).

Microsoft PowerPoint represents one such accessible platform. It is widely used in educational institutions and allows educators to develop interactive learning materials with minimal technical barriers. Recent studies demonstrated that PowerPoint-based games and interactive PowerPoint media can effectively support learning by incorporating interactive features such as animations, action triggers and feedback mechanisms that guide learners through structured content and reinforce understanding. For example, PowerPoint-based problem-based learning games have been shown to improve mathematical problem-solving skills and motivation among secondary students (Mansor & Rosly, 2025), while interactive PowerPoint games incorporating animations and action features have been found to attract student attention and stimulate learning engagement (Budasi et al., 2020). In a study conducted by Wen et al., 2024, they highlighted that Microsoft PowerPoint can serve as an effective instructional tool, providing teaching support and enhancing students' engagement through aesthetic design elements.

The accessibility of PowerPoint-based solutions is particularly important for educational equity. Unlike specialised gaming platforms that require expensive licences, advanced hardware, or extensive technical expertise, PowerPoint-based games can be implemented across diverse educational settings with minimal resource requirements (Fairuzabadi & Supianto, 2019). Malaysian studies have further highlighted infrastructural challenges in educational technology implementation, underscoring the value of accessible platforms such as PowerPoint for widespread adoption (Yong, 2017).

To address this gap, the present study introduces Trigonomaze: The Jungle Maze of Angles, a PowerPoint-based trigonometry game designed to support learning of trigonometric identities and angle-finding skills. The game adopts a maze-based structure in which students progress through a sequence of challenges by solving trigonometry questions

within the given time, receiving immediate feedback and accessing supplemental notes when needed. The combination of these elements encourages focused evaluation and efficient problem-solving while maintaining instructional support through feedback and scaffolding.

Rather than evaluating learning outcomes solely through test scores, this study focuses on students' learning experiences when using the game, including engagement, perceived learning effectiveness, mistake recognition, adaptability and collaboration. Understanding these experiential dimensions is crucial as positive learning experiences are closely linked to motivation, persistence and long-term learning in mathematics.

Problem Statement

Many students continue to experience difficulties with trigonometric identities and angle-related problem-solving under traditional instructional approaches, and educators often face constraints in adopting complex digital tools. Therefore, there is a need for a pedagogically grounded, low-cost and accessible game-based learning solution that can enhance student engagement and support meaningful learning in trigonometry.

Research Objectives

This study aims to develop, implement, and evaluate an innovative trigonometric PowerPoint game designed to enhance students' learning experiences, particularly in terms of engagement, perceived learning effectiveness and support for basic trigonometric identities and angle-finding skills within the Malaysian diploma education context. Building upon established research in educational gaming (Vankúš, 2021) and recent Malaysian studies on mathematics gamification (Anuar et al., 2024; Jutin & Maat, 2024), this research addresses three primary objectives.

1. To examine students' experiences of engagement and overall learning experience when using the PowerPoint-based trigonometry game.
2. To evaluate the cognitive support and adaptability features of the game in enhancing students' conceptual understanding and skill development, particularly in terms of mistake recognition, problem-solving and responsiveness to diverse learning needs.

The findings will provide evidence-based recommendations for educators and policymakers seeking to integrate educational technology effectively while addressing the unique challenges of trigonometric instruction in Malaysian educational settings.

Research Questions

This study is guided by the following research questions:

1. How do students perceive their engagement and overall learning experience when using the PowerPoint-based trigonometry game?
2. How does the PowerPoint-based trigonometry game provide cognitive support and adaptability on enhancing students' conceptual understanding and skill development?

Methods

Research Design

This study employed a descriptive quantitative design using a post-intervention survey to examine students' learning experiences after using the Trigonomaze: The Jungle Maze of Angles game. The focus was on students' engagement, perceived learning effectiveness, mistake recognition, adaptability and collaboration. Data were collected immediately after gameplay.

Design Framework

This study adopts a game-based learning approach grounded in constructivist learning theory, where students actively construct knowledge through interaction, exploration, and feedback (Egara & Mosia, 2025; Prayogi & Dwi Puspita, 2025; Roedavan et al., 2021). In addition to constructivist learning theory, the PowerPoint-based game's instructional design is based on Mayer's Cognitive Theory of Multimedia Learning (CTML) (Mayer, 2021). This theory emphasizes one focus that students can have a more effective way of learning through visual and verbal communication channels to make cognitive load under controlled. The game integrated with visualisation on trigonometric concepts, short text explanations and instant feedback to help the students to choose, organize and gather some knowledge during the game process.

1. **Gamification Elements**
   -Points, badges, leaderboards, timer-based and achievement systems to maintain student engagement, following successful Malaysian implementations (Yung et al., 2020).

2. **Interactive Components**
   -Engages students through maze navigation where each path is unlocked by solving trigonometric problems involving angles, sides, and functions such as sine, cosine, and tangent. The game includes timed quests, scoring systems, and collectible rewards to boost motivation, while adaptive difficulty ensures progressive learning.

3. **Immediate Feedback**
   -Students receive immediate feedback, with correct answers opening new routes and wrong answers triggering hints or obstacles, addressing the need for mistake recognition and correction identified in educational gaming research.

4. **Progressive Learning**
   -Scaffolded difficulty progression from basic trigonometric ratios to complex identities and applications, similar to the multilevel approach used in Malaysian Additional Mathematics gaming (Anuar et al., 2024).

Instructional Design Process

The framework adopted in this study represents a hybrid integration of instructional design and game-based learning principles. It combines instructional design elements to ensure alignment between learning objectives, tasks, feedback, and assessment; game-based learning mechanics to promote motivation, engagement, and progressive learning; and pedagogical foundations grounded in constructivist and experiential learning theories. This framework functions as a learning design model that systematically guides the development of the game's content, mechanics, and intended learning outcomes.

The game development followed a simplified ADDIE (Analysis, Design, Development, Implementation, Evaluation) instructional design model (Rahmawati, Buchori & Wibisono, 2022; Rakasiwi & Muhtadi, 2021). This ADDIE model is to ensure the development process is systematic, pedagogically grounded, and replicable, strengthening methodological consistency:

1. **Analysis:** Identified learning difficulties in trigonometric identities and angle measurement
2. **Design:** Planned learning objectives, game flow, challenge levels, and feedback mechanisms
3. **Development:** Built interactive PowerPoint slides, scoring logic, navigation paths, and feedback screens
4. **Implementation:** Piloted the game with diploma students in a classroom setting
5. **Evaluation:** Collected student feedback using a Likert questionnaire

This process ensured that the game was developed in a structured and pedagogically aligned manner. The game integrates interactive elements including multiple-choice questions, visual animations, immediate feedback mechanisms, and progressive difficulty levels to reinforce trigonometric concepts (Herlansyah & Retnawati, 2024).

Game Design and Development

The trigonometric PowerPoint game was developed following established educational game design principles identified in the comprehensive literature review, with particular attention to accessibility considerations highlighted in Malaysian research (Anuar et al., 2024).

Trigonomaze: The Jungle Maze of Angles is an interactive educational game aimed at making trigonometry interactive, challenging and fun. The goal is for players to find a way through a maze of challenges by solving trigonometry problems so they can advance through it. The game has four unique doors: Door of Sine, Door of Cosine, Door of Tangent and Door of Mastery. At each door, the player will be answering three questions. Players will be given 300 seconds (5 minutes) to solve each question. If they fail or take longer than the time limit, they may use the HELP button key which offers access to supporting notes and instant feedback and informs the player about their errors and improves their problem-solving skills. If answers all three questions correctly, the player obtains a key for accessing the next door. The player repeats this until they advance and cross the fourth door and finish the game. This game makes reviewing trigonometry a fun experience and a good tool for both educators and students.

Figure 1
Game Flow

Samples

A total of 35 diploma-level students participated in this study. All participants had prior exposure to basic mathematical concepts and were enrolled in mathematics courses that required the application of trigonometric knowledge. The study was conducted in an academic environment reflective of Malaysian technical education institutions, where affordable and accessible digital learning solutions are highly valued. Inclusion criteria required that participants were enrolled in trigonometry or related mathematics courses, consented voluntarily to take part in the study, and demonstrated basic familiarity with the PowerPoint interface, which was necessary for navigating the game.

e-ISSN 2600-8572 | DOI: https://doi.org/10.11113/itlj.v10.227

Research Instruments

Data on students' learning experience were collected using a structured questionnaire consisting of 12 items measured on a five-point Likert scale, ranging from 1 = Strongly Disagree to 5 = Strongly Agree. The 12-item Likert scale was developed based on validated instruments used in educational gaming research with particular attention to factors identified as significant in previous studies.

1. Engagement and Motivation: Items measuring student interest and active participation (Yong et al., 2019)
2. Learning Effectiveness: Self-assessment of conceptual understanding improvement
3. Technology Acceptance: Ease of use, usefulness and intention to use similar tools
4. Mistake Recognition: Ability to identify and correct errors, a key factor in mathematical learning
5. Collaborative Learning: Peer interaction and collaboration opportunities
6. Game Adaptability: Flexibility and customization options

The survey was administered immediately after the gameplay session, allowing students to provide timely and reflective feedback on their learning experience.

Data Analysis

Data collected from the 12-item Likert scale questionnaire were analysed using descriptive statistics. Mean scores and standard deviations were computed for each item to summarize students' perceptions of the game in terms of usability, engagement, motivation, and learning effectiveness. Higher mean values indicated more positive perceptions, while standard deviations reflected the degree of response variation among participants. The analysis provided a clear overview of how students evaluated the game as a digital learning tool in the context of trigonometry. The internal consistency of the instrument was evaluated using Cronbach's alpha ($\alpha = 0.85$), indicating acceptable reliability.

Results

The findings in Table 1 of the 12-item Likert scale revealed overwhelmingly positive student responses, with all items scoring above 4.3 on the 5-point scale, indicating strong favourable reactions to the trigonometric PowerPoint game.

Table 1
The Descriptive Statistics of Students' Feedback

No.	Items (Likert scale: 1 – strongly disagree, 5 – strongly agree)	Mean	SD
1.	The game made learning easier and more effective for me.	4.41	0.80
2.	The design and content of the game were engaging and felt relevant to what I was learning.	4.36	0.58
3.	I enjoyed playing the game.	4.45	0.67
4.	The game helped me remember what I learned.	4.50	0.67
5.	Playing the game sparked my interest in the lesson.	4.41	0.59
6.	The game served as a useful review of the learning material.	4.45	0.60
7.	The game positively influenced my perception of the lesson.	4.36	0.73
8.	I was able to identify and correct my mistakes through the game.	4.68	0.57
9.	The game kept me actively involved in the lesson.	4.55	0.60

e-ISSN 2600-8572 | DOI: https://doi.org/10.11113/itlj.v10.227

10.	Playing the game improved my problem-solving skills for trigonometric topic.	4.41	0.67
11.	The game encouraged collaboration and discussion with my peers.	4.36	0.66
12.	The game adapted to my learning pace and needs.	4.36	0.66

The results indicate a high level of student engagement and enjoyment when using the game. Items related to enjoyment and interest recorded strong agreement including "I enjoyed playing the game" (Mean = 4.45, SD = 0.67), "Playing the game sparked my interest in the lesson" (mean = 4.41, SD = 0.59) and "The game kept me actively involved in the lesson" (Mean = 4.55, SD = 0.60). These findings suggest that the game successfully transformed trigonometry practice into an interactive learning experience. The maze-based structure, visual elements, and door-and-key progression encouraged students to remain focused and actively participate throughout gameplay. Students also reported positive perceptions regarding the effectiveness of the game in supporting their learning. High mean scores were observed for "The game made learning easier and more effective for me" (Mean = 4.41, SD = 0.80), "The game served as a useful review of the learning material" (Mean = 4.45, SD = 0.60), and "The game helped me remember what I learned" (Mean = 4.50, SD = 0.67). These results indicate that this game functioned effectively as a reinforcement and revision tool for basic trigonometric identities and angle-finding skills. The structured progression through multiple doors allowed repeated practice of related concepts, supporting retention and confidence.

The strongest outcome of the study relates to students' ability to recognise and correct mistakes. The item "I was able to identify and correct my mistakes through the game" recorded the highest mean score among all items (Mean = 4.68, SD = 0.57). In addition, students agreed that "Playing the game improved my problem-solving skills for the trigonometric topic" (Mean = 4.41, SD = 0.67). These findings highlight the effectiveness of the immediate feedback mechanisms embedded in the game. When students selected incorrect answers or were unable to respond within the allocated time, they were provided with feedback and access to correct answers and supplementary notes. Although overall responses were positive, items related to adaptability and collaboration recorded comparatively lower mean scores. Both "The game encouraged collaboration and discussion with my peers" (Mean = 4.36, SD = 0.66) and "The game adapted to my learning pace and needs" (Mean = 4.36, SD = 0.66) indicated agreement, but with less emphasis compared to engagement- and feedback-related items. These findings suggest that the current game design primarily supports individual learning rather than structured collaborative interaction.

Overall, the results demonstrate that students experienced the game as engaging, supportive, enjoyable, and effective in learning trigonometry**.** The game successfully improved students' learning confidence, motivation, mistake awareness, and perceived understanding**,** reinforcing its potential as a widely accessible and impactful teaching tool.

Discussion

This study examined students' perceptions of a PowerPoint-based trigonometry game, focusing on engagement and learning experience as well as cognitive support and adaptability features. The findings provide meaningful insights into the educational potential of accessible game-based learning tools within mathematics instruction.

Students' Engagement and Enjoyment

The findings indicate that the PowerPoint-based game successfully fostered high levels of engagement and enjoyment among students. Strong agreement on items related to interest, enjoyment and active participation suggests that the maze-based structure and interactive elements created an immersive learning environment. This aligns with previous Malaysian studies reporting that game-based learning can significantly enhance student engagement and motivation in mathematics classrooms (Mansor & Rosly, 2024; Yung et al., 2020). Consistent with broader findings in game-based learning research, the interactive nature of the game helped sustain students' interest in a topic that is often perceived as abstract and challenging (Vankúš, 2021).

e-ISSN 2600-8572 | DOI: https://doi.org/10.11113/itlj.v10.227

Perceived Learning Effectiveness and Conceptual Support

Students also reported positive perceptions regarding the game's effectiveness in supporting their learning. The strong agreement that the game helped them remember what they had learned suggests that structured gameplay can function as an effective reinforcement and revision tool. The positive perceptions reported by students can be attributed to the integration of multimedia elements within the game, including text, graphics, animations and feedback mechanisms (Wen et al., 2024). This align with Mayer's Cognitive Theory of Multimedia Learning which is underscores the process of visual-verbal integration in facilitating retention and increased students' understanding on the topics involved. Similar outcomes have been reported in Malaysian research, where gamification was shown to improve students' understanding and learning experiences in mathematics when aligned with curricular content (Anuar et al., 2024; Jutin & Maat, 2024). The findings also support earlier studies suggesting that educational games can enhance learning effectiveness by integrating practice with meaningful interaction (Ramli et al., 2020).

Mistake Recognition and Problem-Solving Support

One of the most notable outcomes of the study relates to students' strong endorsement of mistake recognition and corrective feedback. The highest-rated item indicated that students were able to reflect on errors and refine their understanding before proceeding. Similar findings have been reported in studies emphasising the role of feedback in educational games for improving problem-solving skills and reducing misconceptions in mathematics learning (Yung et al., 2020; Anuar et al., 2024). This finding also aligns with Mayer's active processing assumption. Students may actively contemplate errors, restructure information, and assimilate feedback into pre-existing knowledge frameworks (Mayor, 2021).

Adaptability and Collaboration

Although overall perceptions were highly positive, items related to peer collaboration and adaptability recorded slightly lower scores. This suggests that students experienced the game primarily as an individual learning tool, with limited opportunities for teamwork learning pathways. This feedback highlights opportunities to enhance future versions by integrating multiplayer challenges, or adaptive difficulty levels to better support diverse learner needs. Previous studies have similarly noted that collaborative dynamics in game-based learning environments require intentional design features such as cooperative tasks or multiplayer elements (Chuah et al., 2021; Yong et al., 2019). These findings highlight opportunities for future refinement, including the integration of collaborative gameplay modes or adaptive learning pathways to better accommodate diverse learner needs.

Implications for Accessible Game-Based Learning

Despite demonstrated effectiveness, the implementation of educational games in mathematics education faces several challenges. Technical barriers include hardware requirements, software compatibility issues, and the need for educator training in game-based pedagogical approaches (Fairuzabadi & Supianto, 2019). Malaysian research has specifically documented these challenges, with mixed-methods studies revealing both opportunities and limitations in deploying digital game-based learning among secondary students (Yong et al., 2019). Research conducted in Miri, Sarawak, Malaysia, has provided comprehensive analysis of how mathematics pedagogy can be improved through computer games engagement (Yong, 2017). The study involved qualitative interviews with teachers and students, revealing both enthusiasm for gaming approaches and concerns about implementation challenges, including technological infrastructure and teacher preparedness. However, several studies also demonstrate successful strategies for overcoming implementation barriers. The development of hybrid approaches that combine conventional methods with digital elements, such as the QR-based card game approach, shows how accessible technologies can be leveraged to create effective educational games without requiring extensive technological infrastructure (Yung et al., 2020).

Conclusion

This study examined students' learning experiences when using Trigonomaze: The Jungle Maze of Angles, a PowerPoint-based game designed to support learning of trigonometric identities and angle-finding skills. The findings

indicate that the game provided a positive and engaging learning experience, particularly in enhancing students' engagement, perceived learning effectiveness, and ability to recognise and correct mistakes. The maze-based structure, time-bound challenges, and immediate feedback successfully transformed traditional trigonometry practice into an interactive and meaningful learning activity. Importantly, the study demonstrates that Microsoft PowerPoint can function as an accessible and low-cost platform for educational game development, offering a practical solution for integrating game-based learning into mathematics classrooms, especially within resource-constrained educational settings.

Limitations and Future Studies

This study has several limitations that should be acknowledged. First, the research was conducted with a relatively small sample size of diploma-level students from a single institution, which restricts the generalizability of the findings. Broader studies involving multiple institutions and different educational levels would provide stronger evidence for the wider applicability of this approach. Second, while the PowerPoint-based game proved effective for individual engagement and mistake recognition, the relatively lower scores for peer collaboration suggest that the current design does not fully support social learning. Finally, the game's adaptability and customization features remain limited, as participants expressed interest in more personalized content and adjustable difficulty levels.

Future studies should address these limitations by exploring the integration of collaborative elements, such as group-based challenges or peer feedback features, to strengthen social learning. Expanding adaptability by incorporating customizable pathways or adaptive difficulty could also improve the inclusivity and long-term effectiveness of the game. Comparative research between PowerPoint-based games and other digital platforms, including mobile or app-based solutions, may provide valuable insights into the relative strengths of different approaches. Additionally, longitudinal studies are recommended to evaluate sustained knowledge retention and the long-term impact of game-based learning in mathematics education.

Conflict of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

Acknowledgment

The authors would like to express sincere appreciation to the participating students for their willingness to be part of this study and for their valuable feedback during the implementation of the game. Special thanks are extended to colleagues who provided constructive input throughout the development and evaluation of the game.

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