INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN PROGRESSIVE EDUCATION & DEVELOPMENT

OPEN ACCESS JOURNAL

Vol 15, Issue 4, (2026) E-ISSN: 2226-6348

A Study on the Use of Game-Based Learning in Solving Hots Mathematics Questions among Unitar International University Students

Rabiha Maya Adiera Binti Ab Rahim, Lee Fei Naa, Tharane Raj Kumar, Maisarah Nurulhusna Binti Mohd Roslan

Faculty of Education and Humanities, UNITAR International University, Malaysia

Corresponding Author Email: rabiha@unitar.my

DOI Link: http://dx.doi.org/10.6007/IJARPED/v15-i4/29114

Published Online: 01 November 2026

Abstract

This study examined the use of game-based learning (GBL) in supporting university students' higher-order thinking skills (HOTS) when solving mathematics questions at UNITAR International University. The study focused on three instructional dimensions—type of educational game, game design features, and lecturer facilitation—and considered perceived usefulness (PU) and perceived ease of use (PEOU) from the Technology Acceptance Model (TAM) as important technology-acceptance constructs. A quantitative descriptive-correlational design was used. The participants comprised the full population of ten mathematics students enrolled at UNITAR International University. Data were collected through a Quizizz game-based activity followed by a structured Google Forms questionnaire using a five-point Likert scale. Descriptive statistics, Cronbach's alpha, Spearman correlation, and regression analysis were reported. The response distributions indicated generally positive perceptions of game-based learning. Students most strongly endorsed the usefulness of immediate feedback, appropriate difficulty, engagement, and lecturer guidance. Reliability was high for Type of Game ($\alpha = .907$), Game Design Features ($\alpha = .931$), Lecturer Facilitation ($\alpha = .940$), and Student Performance ($\alpha = .947$), whereas Mathematics Performance showed weaker internal consistency ($\alpha = .630$). Reported Spearman correlations were positive across the principal constructs, with the strongest association between Mathematics Performance and Student Performance ($r = .70$, $p < .05$). The original report also interpreted the regression findings as indicating an important role for PU and PEOU. Because the sample was very small and complete regression coefficients and indirect-effect estimates were not reported, the findings should be interpreted as preliminary rather than as evidence of causal or generalisable effects. The study nevertheless provides a useful context-specific account of how game design, lecturer facilitation, and technology acceptance may operate together in university mathematics learning.

Keywords: Game-Based Learning, Higher-Order Thinking Skills, Hots, Mathematics Education, Quizizz, Technology Acceptance Model, University Students

Introduction

Mathematics education plays an important role in developing students' analytical reasoning, logical thinking, problem-solving abilities, and capacity to make informed decisions. At the tertiary level, students are expected to move beyond memorising formulas and applying routine procedures towards analysing complex information, evaluating alternative solutions, and applying mathematical concepts to unfamiliar situations. These competencies are closely associated with higher-order thinking skills (HOTS), which are increasingly important in preparing students to address academic and real-world challenges. However, mathematics learning can become challenging when students experience difficulties in understanding abstract concepts, applying mathematical knowledge independently, or maintaining confidence when solving complex problems. These challenges highlight the need for instructional approaches that encourage active participation, meaningful engagement, and deeper mathematical reasoning.

One instructional approach that has received increasing attention is game-based learning (GBL), which integrates game elements and activities into the teaching and learning process to support specific educational objectives. Unlike conventional approaches that may emphasise the transmission of information and repetitive exercises, GBL provides opportunities for students to interact with learning tasks, test possible solutions, receive immediate feedback, and learn from mistakes. These features may promote motivation, engagement, and persistence, particularly when game activities are aligned with the intended learning outcomes (Hartt et al., 2020; Liu et al., 2021; Vankúš, 2021). In mathematics education, digital platforms such as Quizizz can provide an interactive environment in which students respond to questions, monitor their progress, and receive feedback during learning activities. Nevertheless, the educational value of GBL should not be determined solely by students' enjoyment or participation. Its contribution to HOTS also depends on the quality of game design, the cognitive demands of the questions, and the extent to which students are supported in connecting gameplay with mathematical concepts and reasoning.

Despite the potential of GBL, several pedagogical considerations remain important when applying this approach to higher-order mathematics learning. First, different game formats may support different learning purposes, and not every game activity necessarily requires students to engage in analysis, evaluation, or complex problem-solving. Second, game design features, including clear instructions, appropriate difficulty, immediate feedback, and meaningful challenges, may influence how students engage with mathematical tasks. Third, lecturer facilitation remains essential in guiding students through misconceptions, encouraging them to explain their reasoning, and helping them transfer what they learn during gameplay to unfamiliar mathematical problems. In addition, students' acceptance of educational technology may influence their willingness to participate. The Technology Acceptance Model (TAM), developed by Davis (1989), identifies perceived usefulness (PU) and perceived ease of use (PEOU) as important constructs for understanding technology acceptance. Applied to GBL, these constructs provide a useful perspective for examining whether students consider a digital learning platform beneficial to their learning and sufficiently accessible for regular use.

Although previous studies have examined GBL, student engagement, and mathematics learning, further investigation is warranted into how game characteristics, lecturer facilitation, and technology acceptance are associated with students' perceived ability to solve HOTS mathematics questions in a Malaysian higher-education setting. In particular, the relationship between these instructional and technology-related factors deserves attention because a positive gaming experience does not necessarily demonstrate improved mathematical reasoning or objectively measured HOTS achievement. Understanding these relationships can help clarify how digital game-based activities may be incorporated into university mathematics teaching without losing sight of the cognitive demands of higher-order learning.

Against this background, the present study examines the use of GBL in supporting students' performance when solving HOTS mathematics questions at UNITAR International University. Specifically, it investigates the relationships between the type of educational game, game design features, and lecturer facilitation, while considering students' perceptions of usefulness and ease of use within the TAM framework. Using a quantitative descriptive-correlational design, the study draws on responses from ten university mathematics students following a Quizizz-based learning activity and a structured questionnaire. The study seeks to understand how these instructional and technology-acceptance factors relate to students' reported mathematics learning experiences and perceived performance.

The novelty of this study lies in its context-specific integration of game type, game design features, lecturer facilitation, and TAM constructs within an exploratory investigation of HOTS mathematics learning in Malaysian higher education. Rather than treating GBL simply as a motivational tool, the study considers it as an instructional experience shaped by the interaction between game characteristics, educator support, and students' perceptions of technology. Its contribution to the social sciences is to provide preliminary empirical insights into the relationship between educational technology adoption, instructional practices, and students' reported learning experiences in a university context. These insights may inform mathematics educators and educational researchers seeking to design more purposeful digital learning activities. Given the small sample and reliance on self-reported data, the findings are interpreted as exploratory evidence that can inform subsequent research, rather than as proof of causal effects or generalisable improvements in HOTS achievement.

Problem Statement and Research Gap

Although previous literature has reported positive relationships between GBL, engagement, motivation, and aspects of mathematics learning, the source study identifies a more specific problem at the tertiary level: the contribution of GBL to HOTS is not necessarily consistent when students are required to solve complex mathematics problems. Three issues are particularly relevant. First, insufficient lecturer facilitation may leave students unable to connect game activity with formal mathematical principles. Second, game design may not be adequately aligned with the intended learning outcomes. Third, the type of game may impose cognitive demands that do not match the reasoning required by HOTS mathematics questions.

The Technology Acceptance Model (TAM) adds another dimension to this problem. Davis (1989) proposed that perceived usefulness (PU) and perceived ease of use (PEOU) are central

to technology acceptance. In an educational GBL setting, students may be more willing to engage with a game when they believe that it contributes to learning and when the technology can be used without unnecessary difficulty. Thus, the present study addressed a contextual gap by examining how game type, game design, and lecturer facilitation were related to students' reported HOTS mathematics performance, while also considering the perceived usefulness and ease of use of the game.

Purpose, Objectives and Research Questions

The purpose of the study was to examine the use of GBL in supporting students' performance when solving HOTS mathematics questions at UNITAR International University. The objectives were:

To investigate the implications of different kinds of educational games on students' performance in mathematics questions requiring HOTS.

To examine how game features such as feedback, rewards, and challenges relate to students' performance in mathematics tasks requiring HOTS.

To explore how support during GBL helps students succeed in solving mathematics questions involving HOTS.

The corresponding research questions were:

1. What are the effects of different types of educational games on students' ability to solve mathematics questions requiring HOTS?
2. How do game features influence students' performance in mathematics tasks requiring HOTS?
3. In what ways does support during GBL enhance students' success in solving mathematics questions requiring HOTS?

Hypotheses

H1: There is a significant relationship between the type of educational game used and students' performance in mathematics questions requiring HOTS.

H2: There is a significant relationship between game design features and students' performance in mathematics tasks requiring HOTS.

H3: There is a significant relationship between lecturer facilitation and students' performance in mathematics questions involving HOTS.

H4: Perceived usefulness and perceived ease of use mediate the effects of the independent variables on students' intention to adopt GBL, which in turn influences performance in mathematics tasks requiring HOTS.

Literature Review

Game-Based Learning in Mathematics

GBL refers to the purposeful use of digital or non-digital games within a pedagogical setting to support learning. In mathematics, the attraction of GBL lies in its ability to turn abstract or procedural content into interactive tasks. Rather than receiving information passively, students can make choices, test solutions, receive immediate feedback, and continue working after an unsuccessful attempt. The source study connects these features with motivation, confidence, curiosity, collaboration, and persistence (Pan & Ke, 2023; Liu et al., 2021).

Research cited in the source study suggests that different forms of games may support different dimensions of mathematics learning. Puzzle games can foreground patterns and logical reasoning; simulations can provide representations of complex structures and real-world applications; drill-and-practice games can strengthen fluency and accuracy; and cooperative multiplayer games can encourage discussion and shared reasoning (Ahmad & Zainudin, 2022; Ersen & Ergül, 2023; Yusof & Hashim, 2023). The implication is not that one format is universally effective, but that the educational purpose should guide game selection. The literature also indicates the design of a game matter. Clear objectives, appropriate difficulty, timely feedback, scaffolding, progress indicators, and meaningful rewards can shape the quality of the learning experience. When such features are connected to mathematics being learned, gameplay can become a structured environment for inquiry and problem solving rather than an activity that merely rewards speed or competition (Clark et al, 2016; Tokac et al, 2019).

Types of Educational Games

The first independent variable in the study was the type of educational game used. The questionnaire considered puzzle, simulation, drill-based, and multiplayer formats, while Quizizz functioned as the main game-based platform in the research procedure. Puzzle-based activities were associated with critical thinking and logical problem solving. Simulation activities were associated with understanding applications of mathematics in realistic contexts. Drill-based activities were linked with calculation skills, and multiplayer activities with discussion and collaboration.

These distinctions are pedagogically meaningful because HOTS requires students to reason about information and choose strategies rather than merely reproduce memorised procedures. A game that requires students to compare alternatives, interpret representations, explain reasoning, or respond to unfamiliar situations is more closely aligned with HOTS than a game based solely on repetitive recall. The source study cites evidence that matching game format to learning needs may support analytical reasoning, problem solving, curiosity, and independent thinking (Papastergiou, 2013; Vankúš, 2021; Hartt et al., 2020; Angelelli et al., 2023; Asri & Jamaludin, 2022; Demirel & Yilmaz, 2020; Izzati et al., 2022).

Game Design Features

Game design features were the second independent variable. The study focused on clear instructions, appropriate difficulty, immediate feedback, rewards, and sustained engagement. These features correspond with established principles of instructional design. Clear instructions reduce unnecessary extraneous demands; appropriate challenge can keep students within a productive level of difficulty; feedback can identify errors at the point of action; and progress or rewards can provide cues that sustain effort.

Immediate feedback is particularly relevant to mathematics because students can identify an incorrect procedure or interpretation while the problem-solving process is still active. The source study emphasises that feedback can enable students to notice mistakes and learn more efficiently. At the same time, the study notes that rewards and leaderboards should not become substitutes for meaningful cognitive engagement. Deeper thinking is more likely when students must make choices, solve non-routine problems, and respond to unfamiliar

variations rather than simply repeat predictable patterns (Clark et al., 2016; Tokac et al., 2019; Vankúš, 2021).

Lecturer Facilitation

The lecturer's role is central to transforming gameplay into a learning experience. Facilitation begins before gameplay through the selection of an appropriate activity and the explanation of how the game relates to course objectives. During gameplay, lecturers can observe students' reasoning, provide targeted support, ask probing questions, and address misconceptions. After gameplay, structured debriefing can help students connect the decisions made in the game with formal mathematical concepts (Ersen & Ergül, 2023; Yusof & Hashim, 2023).

Related evidence from UNITAR-affiliated research on online learning among students with autism also underscores the importance of structured support and responsive facilitation. Ab Rahim et al (2024), drawing on teachers' perspectives, identified challenges involving student engagement, hyperactivity and inattentiveness, parental involvement, and technical or internet-related difficulties. The study recommended adapting the learning environment, using clear communication and expectations, minimising distractions, providing appropriate accommodations, and recognising students' individual strengths. Although that study addressed autism and online learning rather than university mathematics, its findings are relevant to GBL design because they demonstrate that digital learning activities are embedded within an instructional environment: technology alone does not guarantee engagement or learning. In the present context, lecturer facilitation can therefore include managing cognitive load, clarifying task expectations, reducing avoidable distractions, monitoring participation, and providing flexible support when students encounter technical or learning difficulties.

From a HOTS perspective, facilitation also involves scaffolding. Questioning techniques, reflective tasks, and complex problem-solving activities can encourage students to analyse, evaluate, and create rather than focus only on obtaining the correct answer. The source study therefore treats lecturer facilitation as more than technical assistance: it is a pedagogical bridge between game mechanics and mathematical reasoning (Norliyah Sulaiman & Ahmad Fauzi Mohd Ayub, 2022; Salih, 2014).

Technology Acceptance Model

Davis's (1989) Technology Acceptance Model provides the theoretical foundation for the study. TAM proposes that perceived usefulness and perceived ease of use influence users' acceptance of technology. In the present context, perceived usefulness refers to students' belief that Quizizz can support mathematics learning and problem solving, whereas perceived ease of use refers to the extent to which students perceive the platform as simple to navigate and operate.

TAM is relevant because a technically available game does not automatically become an accepted learning tool. If students perceive the game as useful and easy to use, they may be more willing to participate and sustain engagement. Conversely, technical difficulty or unclear educational value may reduce acceptance. The source study therefore places PU and PEOU

alongside game type, design, and lecturer facilitation in explaining students' responses to GBL.

HOTS and Mathematics Performance

HOTS in mathematics involves processes such as analysing complex information, reasoning through unfamiliar problems, evaluating possible solutions, applying concepts in new situations, and solving non-routine tasks. The source study connects these processes with university-level learning and identifies problem solving, reasoning, critical thinking, and computational thinking as important capabilities (Lovianova et al., 2022; OECD, 2019). Mathematics performance was considered through understanding, problem solving, application, accuracy, and affective outcomes such as confidence and perseverance.

Evidence from a UNITAR International University-affiliated study further suggests that the cognitive demands of mathematics learning should be considered together with students' affective dispositions. Ab Rahim, Kamrozzaman, Taha, and Wahidin (2023) examined 81 secondary school students in the Puchong area and reported moderate positive relationships between mathematics self-efficacy and mathematics achievement ($r = .502$, $p < .01$), as well as between attitudes towards mathematics and achievement ($r = .426$, $p < .01$). The study also reported a positive association between its mathematics-anxiety measure and achievement ($r = .525$, $p < .01$), while noting that this finding differed from much of the literature and should not be generalised across contexts. Particularly relevant to the present GBL study is the finding that self-efficacy was lowest for the item concerning students' confidence in solving HOTS mathematics questions ($M = 2.67$), compared with confidence in learning mathematics generally ($M = 3.57$). This provides a useful local indication that confidence in tackling higher-order mathematics may require deliberate instructional support, rather than being assumed to follow automatically from general mathematics confidence.

GBL may support these outcomes by creating repeated opportunities to attempt problems, receive feedback, revise strategies, and discuss solutions. Nevertheless, the extent of cognitive transfer from game performance to broader mathematics performance remains an empirical question. This distinction is important in interpreting the present findings because the study relied substantially on student perceptions rather than objective pre-test/post-test measures.

The inclusion of locally generated evidence strengthens the contextual basis of the present study. Two recent studies involving UNITAR-affiliated researchers provide complementary evidence. The 2023 mathematics study demonstrated that affective variables, particularly self-efficacy and attitudes, were associated with mathematics achievement among 81 secondary students, while also identifying relatively modest confidence in solving HOTS mathematics questions. The 2024 study of teachers' perspectives on online learning among students with autism highlighted the importance of structured learning environments, clear communication, adaptation, support, and attention to technical barriers. Its conclusions emphasised active involvement and social collaboration alongside teacher–student interaction. Taken together, these local studies support the present framework's emphasis on the interaction between students' psychological dispositions, the design of digital learning environments, and the educator's facilitative role. They do not directly test GBL or Quizizz in

HOTS mathematics, but they provide contextually relevant evidence for why confidence, usability, structured support, and facilitation should be considered when examining digital game-based mathematics learning.

Conceptual Framework

The conceptual framework integrates three instructional independent variables—Type of Educational Game, Game Design Features, and Lecturer Facilitation with TAM constructs and the dependent outcome of students' performance in solving HOTS mathematics questions. The framework assumes that game type and design provide the learning environment, lecturer facilitation connects the activity to mathematical reasoning, and students' perceptions of usefulness and ease of use shape their acceptance of the technology.

Independent variables	Technology-acceptance constructs	Dependent outcome
Type of educational game	Perceived usefulness (PU)	Students' performance in solving HOTS mathematics questions
Game design features	Perceived ease of use (PEOU)	
Lecturer facilitation		

Figure 1. Conceptual framework adapted from the study's original framework.

Methodology

Research Design

The study employed quantitative descriptive-correlational design. The descriptive component was used to summarise participants' demographic characteristics and responses to the questionnaire. The correlational component was used to examine associations among game type, game design features, lecturer facilitation, mathematics performance, and student performance. Regression analysis was also reported to examine the contribution of TAM-related perceptions.

This design was appropriate for the study's stated purpose of identifying patterns and relationships rather than establishing causal effects. The source study followed Creswell and Creswell (2017) in using standardised quantitative instruments and statistical analysis. Because the study involved only ten participants, the results should be treated as a small-scale exploratory investigation.

Research Setting and Participants

The research was conducted at UNITAR International University and focused on students taking mathematics, specifically students in pre-calculus classes. The study originally intended to involve secondary school students at SMK Dharma, but the research site was changed because the required approval from the relevant education authority was delayed. The revised setting provided more accessible consent and allowed the study to proceed within a university context.

The participant population comprised of ten mathematics students. A total population sampling technique was used because the accessible population consisted of only ten students. Thus, all members of the identified population participated. While this approach

provides complete coverage of the accessible group, it does not remove the limitation that the group was small and institution specific.

Instruments

Data were collected using a Quizizz game-based activity followed by a Google Forms questionnaire. The questionnaire was organised into six sections: demographic information; type of educational game; game design features; lecturer facilitation; technology-acceptance perceptions; and student performance in HOTS mathematics. The questionnaire was constructed around the study's conceptual framework and reviewed by academic personnel at UNITAR International University.

Responses to the main measurement items were recorded on a five-point Likert scale ranging from 1 = Strongly Disagree to 5 = Strongly Agree. The Type of Game, Game Design Features, Lecturer Facilitation, Mathematics Performance, and Student Performance constructs each contained five items. The items addressed perceptions such as critical thinking, real-life application, calculation skills, collaboration, clear instructions, appropriate difficulty, immediate feedback, rewards, engagement, lecturer guidance, reflection, usefulness, ease of use, confidence, application to unfamiliar problems, analysis, speed, and perceived improvement.

Research Procedure

Following approval of the research proposal, the researchers implemented an online Quizizz activity designed around mathematics tasks requiring higher-order thinking. Participants received instructions before beginning the activity and were informed that their responses would remain anonymous. After completing the game-based activity, students completed the Google Forms questionnaire. The questionnaire was administered immediately after the activity so that participants could report their perceptions while the experience was still recent.

The completed responses were reviewed, coded, and entered into the Statistical Package for the Social Sciences (SPSS). Descriptive and inferential procedures were then used to examine response patterns, reliability, correlations, and reported regression relationships.

Data Analysis

Frequencies and percentages were used to describe demographic characteristics and item responses. Means and standard deviations were reported in the original study. Because several of the original mean values are internally inconsistent with the corresponding frequency distributions, the present manuscript prioritises the directly reported frequencies and the reported inferential statistics. Where item means are discussed below, they are recalculated from the published frequency distributions solely to improve internal consistency of reporting; no raw respondent-level dataset was available for independent verification.

Cronbach's alpha was used to assess internal consistency. Spearman's rank-order correlation was used to examine the direction and strength of associations among the constructs. Regression analysis was used in the original report to examine the role of perceived usefulness and perceived ease of use. However, the source report does not provide the full

regression output (e.g., unstandardised/standardised coefficients, R^2, F statistics, confidence intervals, or indirect-effect estimates). Accordingly, this manuscript reports the substantive interpretation supplied by the study while avoiding fabrication of statistics that were not available.

Ethical Considerations

The study reported that consent was obtained from participants and relevant university authorities. Participants were informed about the activity and assured of anonymity. Data were collected through an online activity and questionnaire, and the responses were subsequently coded for statistical analysis.

Results

Participant Profile

Ten students participated in the study. The demographic profile shows that four participants (40%) were aged 21–23 and four (40%) were aged 24–26. One participant (10%) was aged 18–20 and one (10%) was aged 27–30. Seven participants (70%) were male and three (30%) were female. Eight participants (80%) were from Education and Humanities and two (20%) were from Business and Management. Nine participants (90%) were reported as diploma-level students and one (10%) as an undergraduate student. Nine participants (90%) reported previous use of educational games in mathematics.

Table 1
Demographic profile of participants (N = 10).

Characteristic	Category	n	%
Age	18–20	1	10
	21–23	4	40
	24–26	4	40
	27–30	1	10
	Above 30	0	0
Gender	Male	7	70
	Female	3	30
Faculty	Education and Humanities	8	80
	Business and Management	2	20
	Information Technology	0	0
Educational level	Diploma	9	90
	Undergraduate	1	10
Prior use of educational games	Yes	9	90
	No	1	10

Item Response Patterns

Participants generally selected Agree or Strongly Agree across the measurement items. For Type of Game, all ten students agreed or strongly agreed that puzzle-based games supported critical thinking, with 40% selecting Agree and 40% selecting Strongly Agree. Simulation games were endorsed by 80% at the two positive response levels (60% Agree; 20% Strongly Agree). Similarly, drill-based games and multiplayer games each received 80% positive responses, while 80% also agreed or strongly agreed that different game types helped them approach problems in different ways.

For Game Design Features, clear instructions received 90% positive responses, appropriate difficulty 80%, immediate feedback 70%, rewards 80%, and sustained engagement 80%. Immediate feedback therefore emerged as a particularly salient feature in the response pattern, although the distribution also indicates some variability in students' experiences.

Lecturer Facilitation was also viewed positively. Ninety percent agreed or strongly agreed that the lecturer clearly explained how to use the game, and all participants agreed or strongly agreed that the lecturer connected the game with mathematical concepts. Seventy percent agreed or strongly agreed that the lecturer provided guidance during gameplay, 80% reported positive responses concerning post-activity discussion, and 80% reported positive responses concerning reflection on mistakes.

Mathematics Performance items were similarly positive. Ninety percent agreed or strongly agreed that the game improved their understanding of mathematics; 90% reported positive responses concerning solving difficult questions and improving problem-solving skills; 70% viewed the game as useful and effective; 80% considered it easy to use with clear instructions; and 90% regarded the interface as user-friendly.

For Student Performance, 80% agreed or strongly agreed that they were confident in solving HOTS mathematics questions, 80% reported that they could apply concepts to unfamiliar problems, 80% reported that they could analyse and interpret complex questions, 80% reported that they could solve problems faster after using the game, and 90% agreed or strongly agreed that their mathematics performance had improved.

Descriptive Statistics

The original report presents item-level means and standard deviations that do not consistently correspond to the reported five-point frequency distributions. For example, an item with 40% Agree and 40% Strongly Agree would have a mean above 4.00 on the stated 1–5 scale, not a mean of 2.20. To avoid reproducing a clear internal inconsistency, the following summary uses means recalculated directly from the reported frequency distributions. These recalculated values should not be interpreted as a substitute for raw-data analysis.

Table 2

Descriptive summary based on the frequency distributions reported in the original study.

Construct	**Indicative item-mean range**	**Overall pattern from reported frequencies**
Type of Game	4.00–4.20	Positive endorsement across all five items
Game Design Features	4.00–4.30	Immediate feedback and clear instructions were strongly endorsed
Lecturer Facilitation	3.80–4.00	Positive responses, with some variation in guidance and reflection
Mathematics Performance	3.90–4.20	Generally positive perceptions of understanding, usefulness and usability
Student Performance	3.90–4.20	Positive perceptions of confidence, application and improvement

The descriptive pattern is therefore broadly consistent: participants tended to report favourable experiences with game-based mathematics learning. The strongest responses were concentrated around the usefulness of feedback, the appropriateness of game difficulty, lecturer support, and students' confidence in addressing HOTS mathematics tasks.

Reliability Analysis

Table 3

Reliability coefficients reported in the study.

Construct	Items	Cronbach's alpha	Interpretation in source report
Type of Game	5	.907	High internal consistency
Game Design Features	5	.931	High internal consistency
Lecturer Facilitation	5	.940	High internal consistency
Mathematics Performance	5	.630	Below conventional .70 benchmark
Student Performance	5	.947	High internal consistency

The reliability analysis indicated strong internal consistency for four constructs: Type of Game (α = .907), Game Design Features (α = .931), Lecturer Facilitation (α = .940), and Student Performance (α = .947). Mathematics Performance had a lower alpha of .630. The source study appropriately noted that the small sample requires caution when interpreting Cronbach's alpha. The comparatively low coefficient for Mathematics Performance also suggests that the five items may not have functioned as a single homogeneous construct and may require refinement in a larger study.

Correlation Analysis

Table 4

Spearman correlations among the five main constructs (N = 10); the source report labels all off-diagonal associations p < .05

Variables	TG	GDF	LF	MP	SP
Type of Game (TG)	1.00	.45	.38	.50	.42
Game Design Features (GDF)	.45	1.00	.60	.55	.58
Lecturer Facilitation (LF)	.38	.60	1.00	.62	.65
Mathematics Performance (MP)	.50	.55	.62	1.00	.70
Student Performance (SP)	.42	.58	.65	.70	1.00

All reported associations were positive. The strongest relationship was between Mathematics Performance and Student Performance (r = .70), followed by Lecturer Facilitation and Student Performance (r = .65), Lecturer Facilitation and Mathematics Performance (r = .62), and Game Design Features and Lecturer Facilitation (r = .60). The weakest reported association was between Type of Game and Lecturer Facilitation (r = .38). The source report interpreted these results as evidence of meaningful relationships among the instructional and outcome variables.

Because the sample consisted of only ten participants, correlation coefficients should be interpreted with considerable caution. P-values and effect estimates can be unstable in such a small sample, and statistically significant results in a small exploratory sample should not be treated as evidence of population-level relationships without replication.

Regression Analysis and TAM-Related Findings

The original study used regression analysis to examine the role of perceived usefulness (PU) and perceived ease of use (PEOU) in the relationship between GBL and mathematics outcomes. The substantive conclusion reported in the study was that students who viewed Quizizz as useful and easy to use tended to report stronger academic outcomes, including greater confidence, accuracy, and analytical performance during complex pre-calculus tasks. The report further interpreted game design features and lecturer facilitation as having stronger links with performance when students perceived the technology as useful and easy to use.

However, the original report does not include the regression coefficient table or the numerical evidence required to evaluate the claimed mediation pathway formally. In particular, no direct, indirect, or total effects are reported, and there are no confidence intervals or bootstrapped indirect effects. Consequently, H4 should be described as receiving preliminary interpretive support in the original report rather than as a statistically demonstrated mediation effect. A future study should use a formal mediation procedure and report the complete regression output.

Discussion

Educational Game Type and HOTS Mathematics

The first research question concerned the contribution of different educational game types to students' ability to solve HOTS mathematics questions. The response distributions were favourable across puzzle, simulation, drill-based, and multiplayer formats. Students particularly endorsed puzzle, drill-based, and multiplayer applications, while simulation and varied game formats also received positive responses. The findings are consistent with the study's literature review, which proposes that different game types can activate different forms of cognitive and social engagement.

Puzzle-oriented activities are conceptually compatible with HOTS because they require students to identify patterns, evaluate possible routes to a solution, and reason through constraints. Drill-based activities may contribute more directly to fluency and calculation accuracy, which can provide a foundation for higher-order problem solving. Multiplayer activities may support HOTS through discussion, explanation, and the social comparison of solution strategies. Simulations may help students connect mathematical representations with real-world contexts. Thus, the findings support a differentiated view of GBL in which the educational purpose should determine the game format rather than treating all games as equivalent.

The positive relationship reported between Type of Game and Student Performance ($r = .42$) provides some quantitative support for this interpretation. Nevertheless, the study did not experimentally compare separate game types. Because Quizizz was the principal platform, the results are better interpreted as students' perceptions of different game characteristics within the GBL experience than as evidence that one specific game type produces greater HOTS gains than another.

Game Design Features and Student Learning

The second research question focused on game features. The strongest response pattern within this construct concerned immediate feedback, followed by appropriate difficulty and sustained engagement. These results reinforce the instructional importance of feedback in mathematics. When feedback is immediate, students can identify errors while the underlying reasoning is still accessible and may revise their approach. Appropriate difficulty is similarly important because tasks that are too easy may not stimulate higher-order reasoning, whereas tasks that are excessively difficult may create frustration.

Rewards received positive responses but were less prominent than feedback and difficulty. This distinction is useful for educational practice. The findings suggest that game mechanics associated with learning support may be more important than competition or external rewards alone. The literature reviewed in the source study likewise indicates that deeper learning comes from meaningful decisions, non-routine problems, and thoughtful responses to feedback rather than from points or leaderboards by themselves (Clark et al., 2016; Tokac et al., 2019).

The reported correlation between Game Design Features and Student Performance ($r = .58$) further indicates that students who viewed the design features more positively also tended to report stronger performance. Again, the cross-sectional and small-sample design means that the direction of influence cannot be established. Students who already feel confident in mathematics may also perceive the game more positively.

Lecturer Facilitation as a Pedagogical Bridge

The third research question examined support during GBL. Participants reported positive experiences with lecturer explanations, connections between the game and mathematical concepts, guidance during gameplay, discussion after the activity, and reflection on mistakes. This is an important finding because GBL does not remove the need for teaching. Instead, the lecturer's role changes from direct transmission of content toward orchestration, scaffolding, questioning, feedback, and debriefing.

The correlation findings provide additional support for the importance of facilitation. Lecturer Facilitation correlated with Mathematics Performance at $r = .62$ and with Student Performance at $r = .65$. These are among the stronger relationships reported in the study. They are consistent with the literature cited in the source report, which argues that structured debriefing and targeted questioning help students connect gameplay decisions with mathematical reasoning (Ahmad & Zainudin, 2022; Ersen & Ergül, 2023; Yusof & Hashim, 2023).

For tertiary mathematics teaching, the practical implication is that lecturers should plan the instructional sequence around the game rather than simply insert a game into an existing lesson. Learning objectives should be communicated before play, misconceptions should be addressed during play, and students should be asked to explain and reflect on strategies after play. Such practices can help preserve the cognitive focus of the lesson.

Perceived Usefulness, Ease of Use, and Technology Acceptance

The findings also support the relevance of TAM to GBL in mathematics. Students generally perceived Quizizz as useful and easy to use, and the source report interpreted PU and PEOU as important factors in the regression analysis. This suggests that educational technology adoption may depend on students' judgement that the tool has a clear academic purpose and can be used without excessive technical effort.

The TAM perspective complements the pedagogical variables rather than replacing them. A game may be easy to use but educationally weak, or educationally valuable but technically difficult. The present framework therefore places usability and usefulness within a broader instructional system involving game design and lecturer facilitation. The reported findings are consistent with this integrated interpretation, although the available regression information is insufficient to verify a formal mediation model.

The 2024 UNITAR-affiliated study also provides a useful contextual reminder for interpreting PEOU. Teachers reported technical and internet-related challenges during online learning, while the study highlighted the importance of access to suitable devices, reliable connectivity, and communication between educators and families. Thus, ease of use should not be reduced to interface simplicity alone; students' ability to access and participate in a digital learning activity may also depend on the wider learning environment and available support.

Implications for Mathematics Education

Implications for Lecturers

Select game formats according to the mathematical learning objective. Puzzle, simulation, drill, and multiplayer formats may serve different cognitive purposes.

Prioritise instructional features such as immediate feedback, appropriate difficulty, clear instructions, and meaningful progression rather than relying only on rewards or competition.

Provide explicit facilitation before, during, and after gameplay so that students connect game decisions with mathematical concepts and HOTS processes.

Use reflective questioning and debriefing to ask students why a solution works, how alternative strategies compare, and how a game-based solution transfers to an unfamiliar problem.

Check perceived usefulness and ease of use when introducing a digital game, because student acceptance can influence sustained engagement.

Implications for Curriculum and Educational Technology Design

For curriculum designers, the study highlights the importance of aligning game mechanics with intended learning outcomes. GBL should be embedded within a broader instructional sequence rather than treated as a stand-alone motivational activity. For educational technology designers, the findings emphasise the value of immediate feedback, adjustable challenge, clear navigation, progress information, and opportunities for students to revisit errors. These features should support the mathematical reasoning process rather than merely accelerate response speed.

The study also contributes a small-scale Malaysian higher-education perspective to the literature on GBL and TAM. Its context-specific findings can be useful for generating hypotheses and designing larger studies involving university mathematics students.

Limitations and Future Research

The most important limitation is the very small sample size (N = 10). Although total population sampling was appropriate for the accessible group, the sample was drawn from a single university context. The findings therefore should not be generalised to university students more broadly. The small sample also limits the stability of reliability coefficients, correlations, and regression estimates.

A second limitation is the reliance on self-reported questionnaire data. Perceptions of confidence, usefulness, ease of use, and performance do not necessarily correspond to objectively measured changes in HOTS. The original study did not provide pre-test/post-test scores or an experimental comparison group. Consequently, the study can describe relationships and perceptions but cannot establish that Quizizz or GBL caused improvements in HOTS.

Third, the study was originally intended for secondary school students but was shifted to university students because of administrative approval constraints. This change reduced comparability with the initial research intention and means that the findings represent tertiary learners rather than the secondary-school population originally envisaged.

Fourth, Quizizz was the principal game-based platform. While this provides a clear case for examining a specific digital learning tool, it limits comparisons across different educational game environments. Finally, the reported regression analysis does not contain sufficient numerical detail to verify the proposed mediation pathway statistically.

Future research should therefore recruit larger and more diverse samples across universities and educational levels. Experimental or quasi-experimental designs could compare GBL with conventional instruction and include objective measures of HOTS before and after intervention. Researchers should also compare different game formats and platforms, investigate longer-term learning outcomes, and combine quantitative data with interviews, observations, or learning analytics. A formal mediation model should report direct, indirect, and total effects with bootstrapped confidence intervals. These improvements would provide stronger evidence concerning how game design, lecturer facilitation, technology acceptance, and HOTS are connected.

Conclusion

This study examined GBL as a pedagogical approach for supporting HOTS mathematics learning among students at UNITAR International University. The findings show generally favourable student perceptions of game type, game design features, lecturer facilitation, mathematics learning, and student performance. Immediate feedback, suitable difficulty, lecturer guidance, and perceived usability were prominent features of the reported learning experience. The reliability results were strong for most constructs, while Mathematics Performance showed a comparatively lower internal consistency.

The reported Spearman correlations indicate positive associations among the principal constructs, with Mathematics Performance and Student Performance showing the strongest relationship. The original regression interpretation further identified perceived usefulness and perceived ease of use as important factors in the GBL experience. Taken together, the findings suggest that effective GBL in mathematics is best understood as an integrated instructional process involving appropriate game design, active lecturer facilitation, and student acceptance of the technology.

At the same time, the study's small sample, reliance on self-report, single-institution setting, and incomplete regression reporting require cautious interpretation. The findings are most appropriately viewed as preliminary evidence and as a basis for more rigorous research. Future studies should use larger samples, objective HOTS assessments, comparison groups, and formal mediation analysis. Within these limitations, the study provides a useful starting point for considering how digital game-based activities can be incorporated into university mathematics teaching without losing sight of the central goal: developing students' capacity to reason, solve unfamiliar problems, and apply mathematical knowledge.

Acknowledgement
The authors would like to thank UNITAR International University for supporting this research.

References

Ab Rahim, R. M. A. B., Rossli, N. N., & Derion, M. G. (2024). The challenges of online learning among autism students during COVID-19 pandemic: Teacher's perspectives. International Journal of Academic Research in Progressive Education and Development, 13(4). https://doi.org/10.6007/IJARPED/v13-i4/22845.

Ab Rahim, R. M. A., Kamrozzaman, N. A., Taha, N. M., & Wahidin, K. N. (2023). The relationship of affective factors in mathematics learning amid pandemic Covid-19. International Journal of Academic Research in Progressive Education and Development, 12(1). https://doi.org/10.6007/IJARPED/v12-i1/16417.

Ahmad, N., & Zainudin, Z. (2022). Game-based learning in mathematics: Enhancing student engagement and performance. Journal of Educational Technology, 18(3), 45–56.

Ajmain, M., Rahman, S., & Idris, H. (2023). Higher-order thinking skills in TVET classrooms: Pedagogical readiness and implementation strategies. International Journal of Vocational Education, 12(2), 77–89.

Angelelli, C. V., Muller de Campos Ribeiro, G., Roris Severino, M., Johnstone, E., Borzenkova, G., & Costa Oliveira da Silva, D. (2023). Developing critical thinking skills through gamification. Thinking Skills and Creativity, 49, 101354. https://doi.org/10.1016/j.tsc.2023.101354

Clark, D. B., Tanner-Smith, E. E., & Killingsworth, S. S. (2016). Digital games, design, and learning: A systematic review and meta-analysis. Review of Educational Research, 86(1), 79–122.

Conmaths. (2023). Mathematics teaching practices for HOTS development. Contemporary Mathematics Education Review, 9(1), 33–48.

Creswell, J. W., & Creswell, J. D. (2023). Research design: Qualitative, quantitative, and mixed methods approaches. Sage.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3), 319–340.

Demirel, M., & Yilmaz, H. (2020). [Reference as cited in the original project report].

Ersen, H., & Ergül, R. (2023). Game-based learning and mathematics performance: A study on conceptual understanding and problem-solving. Eurasia Journal of Mathematics, Science and Technology Education, 19(4), 1–12.

Frontiers in Education. (2024). Game-based learning in higher education: Opportunities and challenges. Frontiers in Education, 9, 112–124.

Hartt, M., Hosseini, H., & Mostafapour, M. (2020). Game on: Exploring the effectiveness of game-based learning**.** Planning Practice & Research, 35(5), 589–604. https://doi.org/10.1080/02697459.2020.1778859

Izzati, G. N., Dwijanto, D., & Cahyono, A. N. (2022). The effectivity of problem-based learning assisted by snakes and ladders games on students divergent thinking ability. Jurnal Pijar MIPA, 17(6), 732–736. https://doi.org/10.29303/jpm.v17i6.4177

Khairuddin, N. S., & Mailok, R. (2020). Pembelajaran berasaskan permainan dalam mata pelajaran Sejarah menggunakan teknik mnemonik: Game based learning in History subjects using mnemonic techniques. Journal of ICT in Education, 7(1), 9–15. https://doi.org/10.37134/jictie.vol7.1.2.2020

Liu, Y. C., Wang, W. T., & Lee, T. L. (2021). An integrated view of information feedback, game quality, and autonomous motivation for evaluating game-based learning effectiveness. Journal of Educational Computing Research, 59(1), 3–40. https://doi.org/10.1177/0735633120952044

Lovianova, I. (2022). Developing higher-order thinking skills in mathematics education. Journal of Pedagogical Research, 6(2), 45–59.

Marzuki, A., Syamsuddin, S., & Sukmawati, R. (2025). Game-based learning as a tool for motivation in mathematics classrooms. Indonesian Journal of Mathematics Education, 14(1), 22–35.

Mohd Asri, A. S., & Jamaludin, K. A. (2022). Potential Scratch games in developing students' thinking skills. Malaysian Journal of Social Sciences and Humanities (MJSSH), 7(12), e002004. https://doi.org/10.47405/mjssh.v7i12.2004

Mohamad, A., & Nasri, N. (2025). Mathematics as a foundation for critical thinking in education. Malaysian Journal of Education, 50(2), 101–115.

Pan, X., & Ke, F. (2023). Game-based learning in mathematics: Effects on confidence and collaboration. Computers & Education, 190, 104–118.

Rajendran, N., & Idris, N. (2008). Critical thinking and creativity in mathematics education. Malaysian Journal of Learning and Instruction, 5, 25–45.

Revista de Psicodidáctica. (2024). Game-based learning and HOTS development in higher education. Revista de Psicodidáctica, 29(1), 15–30.

Salih, M. (2014). Facilitation strategies for HOTS in mathematics classrooms. International Journal of Instruction, 7(2), 45–58.

Sulaiman, N., & Mohd Ayub, A. F. (2023). Teacher's perception towards teaching and learning practice based on HOTs in mathematics. Contemporary Mathematics and Science Education, 4(1), ep23015. https://doi.org/10.30935/conmaths/13074OECD. (2019). OECD learning compass 2030: A framework for student competencies. Organisation for Economic Co-operation and Development.

Shamsuar, A. (2024). Interactive learning through educational game design. Journal of Higher Education Pedagogy, 11(3), 66–78.

Tokac, U., Novak, E., & Thompson, C. G. (2019). Effects of game-based learning on mathematics achievement: A meta-analysis. Journal of Computer Assisted Learning, 35(3), 407–420.

UiTM SIGCS. (2023). Game-based learning in mathematics: Instructor facilitation and student outcomes. Universiti Teknologi MARA Special Interest Group in Computer Science.

Vankúš, P. (2021). Influence of game-based learning in mathematics education on students' affective domain: A systematic review. Mathematics, 9(9), 986. https://doi.org/10.3390/math9090986

Yu, Z., Gao, M., & Wang, L. (2021). The effect of educational games on learning outcomes, student motivation, engagement and satisfaction. Journal of Educational Computing Research, 59(3), 522–546. https://doi.org/10.1177/0735633120969214

Wong, S. L., & Osman, R. (2018). Digital games in Malaysian classrooms: Opportunities and challenges. Malaysian Online Journal of Educational Technology, 6(2), 1–15.

Yusof, N., & Hashim, H. (2023). Technology acceptance and game-based learning in mathematics education. International Journal of Emerging Technologies in Learning, 18(5), 55–67.