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Leveling up learning effectiveness in STEM education through gamification: an empirical study on behavioral intention and digital literacy among undergraduate students in Kuwait

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Introduction: This study seeks to investigate the influence of gamification on learning effectiveness in STEM education among undergraduate students in Kuwait. Specifically, the present research explores how various constructs —performance expectation, effort expectation, social influence, and digital literacy—impact students' behavioral intention and willingness to adopt gamification as an integrated part of their learning process in mathematics courses. A series of hypotheses are developed to explore direct and indirect relationships between variables.

Methods: A cross-sectional quantitative study is conducted using a structured questionnaire administered to undergraduate students enrolled in mathematics courses at private universities in Kuwait. The questionnaire is designed based on an extension of the Unified Theory of Acceptance and Use of Technology (UTAUT) framework, to further measure the impacts of learning motivation, learning enjoyment, and digital literacy. Data are analyzed using partial least squares structural equation modeling (PLS-SEM) to validate the relationships between the constructs and evaluate the overall model fit.

Results: Findings reveal that two key factors—performance expectancy ($\beta = 0.674, p < 0.001$) and learning motivation ($\beta = 0.562, p < 0.001$)—have substantial direct impacts on students' behavioral intention to use gamification in their learning. Moreover, effort expectancy is shown to have a positive influence on learning enjoyment ($\beta = 0.399$, $p < 0.001$), while social influence also plays a significant role in enhancing learning enjoyment ($\beta = 0.099$, $p = 0.029$). Interestingly, in this study, we also find that behavioral intention is a strong predictor of the intention to adopt gamification in learning ($\beta = 0.789$, $p < 0.001$). Results also highlight indirect effects, with learning motivation bridging performance expectancy and behavioral intention.

Discussion: Performance expectancy and learning motivation are two primary indicators for students' behavioral intentions to adopt gamification in STEM education. Thus, by utilizing gamified learning tools to boost motivation and enjoyment, educators can significantly improve student engagement and their willingness to use gamification as a learning tool. In order to most effectively leverage the potential for gamification, it is necessary for educators to focus on strategies that not only enhance the perceived benefits of gamification, but also increase students' intrinsic motivation.

KEYWORDS

gamification, stem education, digital literacy, behavioral intention, learning effectiveness, UTAUT

1 Introduction

Games have been a fundamental aspect of human culture for centuries, and with technological advancements, their presence has only grown to become more embedded in our modern lives. In an educational context, it's imperative to adopt a progressive approach, where teaching and learning evolve alongside these rapid transformations in technology to help create a more dynamic and engaging educational experience (Fatima et al., 2024; Ahmed et al., 2025).

To fulfill the demands of modern learners, education—both the act of teaching and the process of learning—needs to promote creativity, innovativeness, and adaptability, thereby effectively addressing current and future educational limitations (Manurung and Tadulako, 2012; Anaktototy, 2023). Conventional teaching strategies are often outdated and no longer aligned with the needs, expectations, and learning preferences of today's students (Mokhtar, 2016; Mohzan and Zubir, 2019). Therefore, educators must consider making the shift toward enforcing active learning strategies that engage students and promote critical thinking (Taylor, 2014). Studies have shown that innovative teaching approaches can positively influence students' motivation and their self-study skills abilities (Van, 2020; Alshammari et al., 2025). Such approaches include e-learning, problem-based learning, and role-playing exercises, which focus on the development of necessary higher-order skills, such as teamwork, creative problem-solving, and digital literacy, which shape student success in our modern society (Dawo and Sika, 2021). These modern methods of teaching prepare students to develop problem-solving mindsets in changing global contexts (Van, 2020; Dawo and Sika, 2021).

The concept of gamification is currently portrayed as a leading trend in education. It is based on the idea of enforcing game design principles and elements in non-game systems, with the aim of increasing the engagement and motivation of learners (Christopoulos and Mystakidis, 2023; Wulan et al., 2024). This gamified-led approach is of particular interest to students who've grown up surrounded by digital technology, also referred to as digital natives (Kiryakova et al., 2014; Chitra, 2020). Studies experimenting with gamification across various disciplines and educational levels are revealing promising outcomes. This includes an overall improvement in students' learning experience, engagement, motivation, and performance (Figg and Jaipal-Jamani, 2018; Thurston, 2018; Chitra, 2020; Li et al., 2023; Zeybek and Saygi, 2023; Jaramillo-Mediavilla et al., 2024). Despite the positive results, it is imperative that further research be directed toward the long-term educational impact of gamification, confirm its potential to teach digital literacy skills, and address any possible drawbacks (Dichev and Dicheva, 2017; Harris and Redlo, 2021).

From e-learning platforms to entrepreneurship and science, gamification has been constantly applied to explore its impact across the disciplines (Bouchrika et al., 2019; Kalogiannakis et al., 2021). This also includes the fields of computer science, medicine, biology, and mathematics (Nurtanto et al., 2021; Gamarra et al., 2021; Abdulla, 2022). Educational gamification is shown to be associated with enhanced student involvement, improved academic performance, increased engagement, and a more enriching learning experience (see, for example, Bai et al., 2020; Manzano-León et al., 2021). However, to effectively measure how well gamification achieves its objectives, careful consideration of its design and integration within existing educational frameworks must be in place (Sanmugam et al., 2015; Dichev and Dicheva, 2017).

As concluded by a study conducted by Bai et al. (2020), the use of gamified tools is shown to boost enthusiasm, encourage goal setting, and provide instant feedback. However, the success associated with the implementation of gamification depends critically on a number of factors, including user type, academic field, and design principles (Smiderle et al., 2020; Li et al., 2023). The influence of learners' characteristics, namely personality traits and player type, also impacts the learning outcomes (Denden et al., 2022). Additionally, the effect on student participation can differ depending on whether students are driven by intrinsic or extrinsic motivation (Al-Kenane et al., 2025; Buckley and Doyle, 2016). Therefore, to determine the best strategies for integrating gamification technology in education, it is necessary to explore different aspects of user behavior and intentions (Jang et al., 2015; Yushaa et al., 2021).

In pursuit of innovation and academic excellence, our goal in this study is to utilize an extension of the Unified Theory of Acceptance and Use of Technology (UTAUT) model to comprehensively explore the impact of a self-learning gamification tool on the user behavior and behavioral intention of undergraduate students in Kuwait, specifically in STEM courses, and incorporate two additional constructs: digital literacy and digital citizenship behavior. Digital literacy refers to the skills and knowledge required to effectively use digital tools, whereas digital citizenship behaviors encompass the responsible and ethical use of technology (Mokhtari, 2023). Further, by utilizing machine learning algorithms, this study seeks to identify features that would potentially contribute to enhanced learning effectiveness. The remainder of this paper is structured as follows: Section 2 outlines the methodology, Section 3 presents the results, Section 4 discusses the findings, and Section 5 concludes the study.

2 Method

2.1 Study design and setting

The study is designed to employ a quantitative method design with the aim of investigating the impact of gamification on learning effectiveness in STEM education. We adopt a cross-sectional approach, where data is collected at a single point in time to explore the relationships between various constructs related to students' behavioral intention and involvement in gamified learning activities within mathematics courses. This research was initiated at private universities in Kuwait, where the participants are students enrolled in mathematics courses. During their learning activities, students were encouraged to engage in gamification-based learning exercises that were integrated into the teaching process to enhance their engagement and motivation in mastering mathematical concepts. The gamification elements included activities designed to make learning more interactive and enjoyable, in alignment with the study's goal of evaluating the effectiveness of these methods in improving learning outcomes.

2.2 Sampling technique

A convenience sampling technique was utilized in this study, as the primary objective was to validate a questionnaire designed to assess the impact of gamification on enhancing learning effectiveness in STEM education. All the students registered in the selected mathematics courses were invited to participate, ensuring that the sample represented a range of learners exposed to gamified learning activities. This non-probability sampling method was chosen because of its ease of access to participants and its relevance to the study's validation goals. A total of 145 undergraduate students from various institutions in Kuwait participated in the study. As shown in Table 1, the majority of the respondents were female (53.1%) and 46.9% were male. Most participants were between the ages of 18–20 (44.8%) and 21–25 (34.5%). Academic level distribution showed that sophomores constituted the largest group (44.1%), followed by juniors (26.2%), and freshmen (22.8%). The GPA distribution indicated that 59.3% of the students had a GPA between 2 and 3, while 29.7% had a GPA between 3 and 4. A significant majority of students (97.2%) accepted the concept of gamification as a learning tool "*Do you believe gamification improves student engagement?*", reflecting the widespread approval of the intervention among the study sample.

TABLE 1 Demographics.

Demographic	Overall (N = 145)
Gender	
Male	68 (46.9%)
Female	77 (53.1%)
Age	
Less than 18	5 (3.4%)
18 to 20	65 (44.8%)
21 to 25	50 (34.5%)
26 to 30	13 (9.0%)
More than 30	12 (8.3%)
Academic Level	
Freshman	33 (22.8%)
Sophomore	64 (44.1%)
Junior	38 (26.2%)
Senior	10 (6.9%)
GPA	
Less than 1	1 (0.7%)
1 to less than 2	15 (10.3%)
2 to less than 3	86 (59.3%)
3 to 4	43 (29.7%)
Gamification acceptance	
Yes	141 (97.2%)
No	4 (2.8%)

2.3 Data collection

The data collection for this study was methodically carried out among students enrolled in mathematics courses at the end of the semester. A structured questionnaire, detailed in Appendix, was distributed anonymously to gather student feedback on the effectiveness of gamification in enhancing their learning experience. The responses gathered will capture insights into students' perceptions of the learning environment and contribute significantly toward the understanding of gamifications' role in enriching their learning experience.

2.4 Research model

To establish a theoretical framework for the design and construction of our research hypotheses, this study begins by providing an overview of the UTAUT model, followed by the possible interactions between various variables in the model. Subsequently, statistical analysis of the quantitative data will be performed to provide insights that supports our findings.

The Unified Theory of Acceptance and Use of Technology (UTAUT) model has been widely used to understand the adoption of technology in different contexts, including e-learning systems, mobile shopping and health information technology (Kijsanayotin et al., 2009; Yang, 2010; Abbad, 2021). Wills and El-Gayar (2008) used UTAUT to explore how medical professionals embrace electronic health records, while Diño and Guzman (2015) applied the model to understand older adults' attitudes toward telehealth services. In an educational context, Chao (2019) employed UTAUT to investigate students' acceptance of mobile learning platforms.

This UTAUT model, shown in Figure 1, was first introduced by Venkatesh et al. (2003), and it proposes that performance expectancy, effort expectancy, social influence, and facilitating conditions are the key determinants of user acceptance and technology use. UTAUT is shown to provide a wider understanding and prediction in explaining behavioral intentions and the actual usage of technologies. However, factors may have varying importance across different populations and contexts. For instance, effort expectancy was found to be insignificant for older adults' computer acceptance (Nägle and Schmidt, 2012), whereas it was a significant predictor of ICT integration (Birch and Irvine, 2009).

The original UTAUT model has also seen some extensions by incorporating additional factors. Chao (2019), for example, expanded the model by incorporating factors like enjoyment and perceived risk. On the other hand, Qendraj et al. (2022) combined the UTAUT model with other analytical approaches, such as fuzzy Z-AHP. Some studies have explored the UTAUT even further; Bervell and Umar (2017) delved into non-linear relationships within the UTAUT model, while Oliveira et al. (2019) applied it specifically to gamification contexts. More recently, Juliansyach and Christiarini (2024) used "UTAUT2"—an enhanced version of the original model—to study mobile gaming apps. This body of literature highlights UTAUT's relevance and adaptability in offering valuable insights into technology acceptance across diverse domains and user groups.

Analytically, Partial Least Squares (PLS) is a statistical technique that is generally used to identify the possible interactions between various variables in the UTAUT model. To date, PLS has been used in various fields: accounting, marketing, and even genomics (Graber, 2009; Boulesteix and Strimmer, 2007; Lee et al., 2011). This technique is particularly beneficial for analyzing complex datasets. It can handle small sample sizes, missing data points, and multicollinearity with relative ease (Jiang and Xia, 2003; Pirouz, 2006). The flexibility offered by PLS allows one to tackle more intricate research models and explore moderating and mediating relationships that might otherwise be difficult to untangle (Lee et al., 2011). PLS is also known for its simplicity, reliability, and predictive power (Jiang and Xia, 2003; Kumar, 2021). In signal processing applications, PLS has been shown to outperform traditional least squares methods in certain situations (Ham and Kostanic, 1996). However, it's important to note that PLS does have its limitations. Notably, its inability to provide quantitative explanations for the relationships it uncovers between variables (Jiang and Xia, 2003). Thus, results must be interpreted with cautious means, and other analytical techniques might be required for a more comprehensive understanding.

2.4.1 Questionnaire design

The questionnaire used in our study was designed to capture the essence of the UTAUT framework while also exploring additional factors related to student involvement in the learning environment, which we believe is crucial in the context of gamified learning. Specifically, the questionnaire is measuring the following constructs.

- Behavioral Intention (BI),
- Effort Expectancy (EE),
- Intention to Use Gamification in Learning (IUG),
- Performance Expectancy (PE), and
- Social Influence (SI).

In addition to the constructs of the UTAUT model, the questionnaire included additional constructs to measure:

- Learning Enjoyment (LE),
- Learning Motivation (LM), and
- Level of Digital Literacy (LDL), in relation to gamified learning environment.

Each construct consists of three items, with responses measured on a five-point Likert scale ranging from strongly agree to strongly disagree. This scaling will allow us to evaluate students' attitudes and experiences with gamified activities and their impact on learning effectiveness.

In the context of gamified learning environments, digital literacy is a foundational skill that significantly shapes how students interact with, navigate, and benefit from educational technologies. As defined by Harris and Redlo (2021), digital literacy extends beyond basic technical skills to include the capacity to critically evaluate, adapt, and engage with digital content and tools in meaningful ways. Given that gamification involves the integration of interactive, tech-based elements—such as dashboards, leaderboards, and multimedia interfaces—the learner's digital proficiency can impact both the usability and perceived enjoyment of such platforms. Prior studies (e.g., Smiderle et al., 2020; Denden et al., 2022) emphasize that students with higher digital literacy are more likely to engage actively in technology-enhanced learning environments, including gamified systems. Therefore, incorporating Level of Digital Literacy (LDL) into the extended UTAUT framework provides a more comprehensive understanding of behavioral intention and engagement in gamified STEM education.

While Behavioral Intention (BI) and Intention to Use Gamification in Learning (IUG) may appear conceptually similar, we distinguish between them based on their temporal and contextual framing. Behavioral Intention refers to students' general willingness or predisposition to engage with gamified STEM learning activities, reflecting internal motivation and perceived value. In contrast, Intention to Use Gamification captures students' future-oriented commitment to adopt and apply gamified tools within actual learning settings when opportunities arise. This distinction aligns with previous extensions of the UTAUT model that differentiate between intention formation (BI) and behavioral execution or implementation (e.g., Oliveira et al., 2019; Vanduhe et al., 2020). Including both constructs allows for a more nuanced understanding of how motivational readiness translates into concrete learning behavior in gamified environments.

2.4.2 Study hypotheses

Based on our literature review and the conceptual framework of the Unified Theory of Acceptance and Use of Technology (UTAUT)

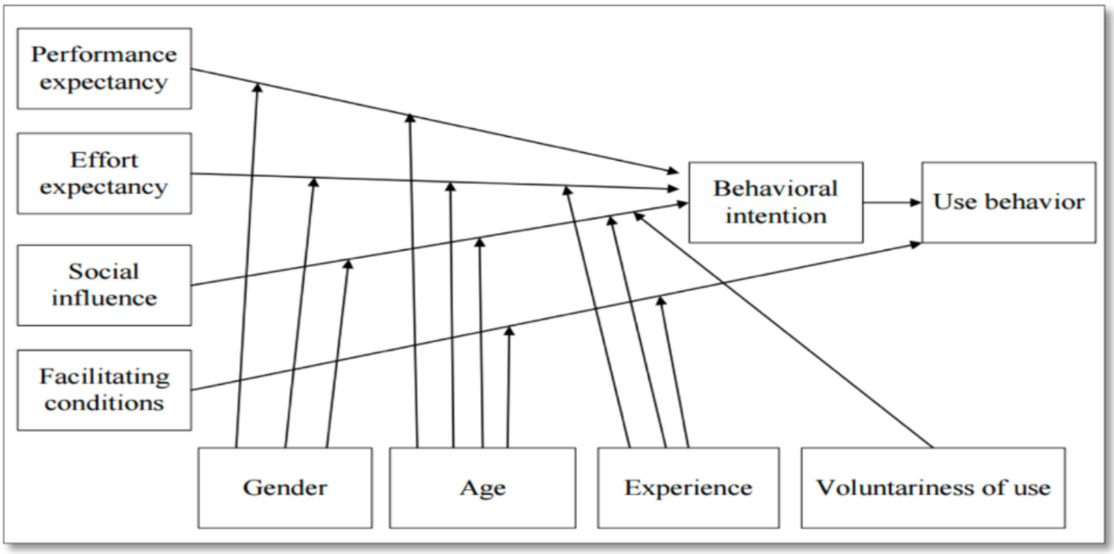

FIGURE 1
Unified theory of acceptance and use of technology (UTAUT). From Venkatesh et al. (2003).

Venkatesh et al. (2003) (see Figure 1, Venkatesh et al., 2003), a series of hypotheses are developed to explore how gamification might enhance learning effectiveness in STEM education. The hypotheses below seek to identify the relationships between various factors that influence students' adoption of gamified learning approaches.

H1: Performance Expectancy (PE) has a positive effect on Learning Motivation (LM).
H2: Effort Expectancy (EE) has a positive effect on Learning Motivation (LM).
H3: Effort Expectancy (EE) has a positive effect on Learning Enjoyment (LE).
H4: Social Influence (SI) has a positive effect on Learning Enjoyment (LE).
H5: Level of Digital Literacy (LDL) has a positive effect on Learning Motivation (LM).
H6: Level of Digital Literacy (LDL) has a positive effect on Learning Enjoyment (LE).
H7: Learning Motivation (LM) has a positive effect on Learning Enjoyment (LE).
H8: Learning Motivation (LM) has a positive effect on Behavioral Intention (BI).
H9: Learning Enjoyment (LE) has a positive effect on Behavioral Intention (BI).
H10: Behavioral Intention (BI) has a positive effect on the Intention to Use Gamification in Learning (IUG).

To put our hypotheses to the test, we use Partial Least Squares Structural Equation Modeling (PLS-SEM). This powerful analytical tool allows us to evaluate the complex relationships between the study variables, embracing direct and indirect effects on learning effectiveness and students' willingness to adapt gamified approaches in STEM education.

2.4.3 Validation of the questionnaire—reliability and validity

Our questionnaire is designed to measure the impact of gamification on enhancing learning effectiveness in STEM education. To ensure validity and reliability, each construct used in the questionnaire is assessed. The reliability of the constructed is measured by examining two key metrics: Cronbach's alpha and composite reliability (ρc). The results demonstrated excellent internal consistency, with Cronbach's alpha values exceeding the standard threshold of 0.7 (Hair et al., 2014). Behavioral Intention (BI), for instance, had a Cronbach's alpha of 0.885, and Learning Motivation (LM) scored 0.918. Similarly, composite reliability was found to be high, which further indicates the strong internal consistency of our measures [e.g., Effort Expectancy (EE) had a composite reliability of 0.901 and Learning Enjoyment (LE) had 0.933].

Validity is approached from two angles: convergent and discriminant. For convergent validity, we examined the Average Variance Extracted (AVE) for each construct. In our questionnaire, each construct was found to exceed the recommended measure of 0.5 (Hair et al., 2017). Behavioral Intention (BI) boasted an AVE of 0.814, while Performance Expectancy (PE) had an AVE of 0.833. This confirms that the constructs are adequately capturing the variance in our data.

For discriminant validity, we employed the Fornell-Larcker criterion (Fornell and Larcker, 1981). This compares the square root of AVE for each construct against its correlation with other constructs. In our analysis, clear distinctions between constructs were revealed. To see this, Learning Motivation (LM) had a square root of AVE of 0.903, which exceeded its correlation with Effort Expectancy ($r = 0.763$), confirming its unique contribution to our model.

These results confirm that our questionnaire is a reliable and valid tool for assessing the effectiveness of gamified learning in STEM education.

2.4.4 Partial least squares model

Using the SmartPLS software, we employ Partial Least Squares Structural Equation Modeling (PLS-SEM) in order to analyze the relationships amongst the study constructs and validate the proposed model. This method is particularly suitable for handling complex models with multiple interrelated constructs and its ability to simultaneously assess both our measurement model (how well our indicators represent the constructs) and our structural model (the relationships between constructs), in addition to, handling relatively small sample sizes and its robustness in modeling relationships between latent variables (Lee et al., 2011; Kumar, 2021). This technique allows us to explore the direct, indirect, and mediating effects of various factors on students' behavioral intentions and learning outcomes in gamified environments.

The study design is cross-sectional, capturing a snapshot of students' attitudes and experiences at a particular point in time. The data collection process involves an online survey that targets undergraduate students enrolled in mathematics courses at private universities in Kuwait. For a comprehensive analysis, we choose to employ a suite of analytical tools such as MS Excel, SPSS, SMARTPLS, and JAMOVI. This multi-faceted analytical approach allows us to thoroughly examine the key factors influencing students' behavior and intentions toward gamification in STEM education, as derived from our modified UTAUT model.

3 Results

3.1 Descriptive statistics, reliability, and validity

Table 2 outlines the descriptive statistics, construct reliability, and validity of the key variables of interest. Behavioral Intention (BI) emerged as a standout construct, with an average score of 4.05 (SD = 0.893). This suggests a strong inclination among students to engage with gamified learning environments. The construct's outer loadings, ranging from 0.893 to 0.918, indicate robust indicator reliability. All constructs demonstrated excellent reliability; Cronbach's alpha values for all constructs exceed the threshold ($\rho c > 0.7$), with standout performances from Behavioral Intention ($\alpha = 0.885$) and Learning Motivation ($\alpha = 0.918$). Composite reliability scores were equally strong, spanning from 0.848 to 0.948, further confirming the internal consistency of our measures. Moreover, Convergent validity, as measured by Average Variance Extracted (AVE) demonstrates that our constructs effectively capture the variance in our data, given that all constructs exceeded the 0.5 benchmark (Hair et al., 2017).

3.2 Discriminant validity

Discriminant validity is assessed using the Fornell-Larcker criterion as displayed in Table 3, where the square root of AVE for each construct is compared against its correlation with other constructs. Results show that the diagonal values (square root of AVE) for each construct are higher than off-diagonal correlations. This confirms that each construct in our model is distinct from the others. For instance, Behavioral Intention had a square root AVE of 0.902, which is greater than its correlation with other constructs, including Effort Expectancy ($r = 0.763$) and Learning Motivation ($r = 0.791$), satisfying the criterion for discriminant validity. These findings give us confidence in the uniqueness of each construct and its contribution to our overall model. They provide a solid foundation for interpreting the relationships between variables and drawing meaningful conclusions about the factors influencing gamification adoption in STEM education.

3.3 Path coefficients

As presented in Table 4 and Figure 2, the analysis of path coefficients reveals several significant relationships. Performance Expectancy (PE) exhibits a strong positive influence on Learning Motivation (LM) ($\beta = 0.674$, $p < 0.001$), confirming H1. This supports the idea that students who perceive gamification as beneficial to their academic performance are more motivated to engage in it. However, Effort Expectancy (EE) does not have a significant effect on Learning Motivation ($\beta = 0.048$, $p = 0.667$), leading to the rejection of H2. The non-significant result for H2 suggests that ease of use alone may not be a sufficient motivator for students when deciding to engage in gamification in STEM education.

However, Effort Expectancy (EE) significantly influence Learning Enjoyment (LE) ($\beta = 0.399$, $p < 0.001$), supporting H3, indicating that students are more likely to enjoy gamified activities when they perceive them as easy to use. Social Influence (SI) also has a small but significant effect on Learning Enjoyment ($\beta = 0.099$, $p = 0.029$), supporting H4. This suggests that peer or instructor encouragement positively affects students' enjoyment of gamified learning tools.

The relationship between learning motivation and Behavioral Intention (BI) is strong and significant ($\beta = 0.562$, $p < 0.001$), confirming H8. Additionally, Learning Enjoyment positively influences Behavioral Intention ($\beta = 0.299$, $p < 0.001$), supporting H9. The strong path from Behavioral Intention to the Intention to Use Gamification (IUG) ($\beta = 0.789$, $p < 0.001$) provides further support for H10, highlighting the importance of students' intention to continue using gamified tools for learning.

3.4 Indirect and mediating effects

Several mediating effects are observed (Table 5). Learning Motivation mediated the relationship between Performance Expectancy and Behavioral Intention ($\beta = 0.299$, $p < 0.001$), demonstrating that students' perceptions of the utility of gamification can enhance motivation, which in turn strengthens their intention to use it. Learning Enjoyment also acts as a mediator between Learning Motivation and Behavioral Intention ($\beta = 0.236$, $p < 0.001$), suggesting that the more students

TABLE 2 The descriptive statistics as well as the construct reliability and validity values.

Construct	Item	Mean	Standard deviation	Outer loadings	VIF	Cronbach's alpha	Composite reliability (rho a)	Composite reliability (rho c)	Average variance extracted (AVE)
Behavioral intention (BI)	BI1	4.055	0.893	0.893	2.502	0.885	0.888	0.929	0.814
	BI2	3.979	0.936	0.894	2.363				
	BI3	3.917	0.929	0.918	2.816				
Effort expectancy (EE)	EE1	4.090	0.901	0.858	1.995	0.836	0.843	0.901	0.753
	EE2	4.186	0.925	0.843	1.775				
	EE3	4.083	0.906	0.901	2.226				
Intention to use gamification in learning (IUG)	IUG1	4.055	0.908	0.891	2.311	0.864	0.864	0.917	0.786
	IUG2	3.965	0.964	0.898	2.433				
	IUG3	3.959	0.893	0.871	2.030				
Learning enjoyment (LE)	LDL1	3.972	1.010	0.936	3.881	0.892	0.892	0.933	0.823
	LDL2	4.076	0.947	0.913	3.172				
	LDL3	4.159	1.008	0.930	3.088				
Learning motivation (LM)	LE1	4.097	0.912	0.903	2.579	0.886	0.890	0.930	0.815
	LE2	4.147	0.879	0.925	3.173				
	LE3	4.035	0.858	0.893	2.463				
Level of digital literacy (LDL)	LM1	4.097	0.920	0.883	2.333	0.918	0.929	0.948	0.859
	LM2	4.110	0.880	0.918	2.904				
	LM3	4.041	0.916	0.907	2.553				
Performance expectancy (PE)	PE1	4.132	0.865	0.900	2.756	0.900	0.906	0.937	0.833
	PE2	4.028	0.924	0.933	3.247				
	PE3	4.028	0.989	0.904	2.594				
Social influence (SI)	SI1	3.324	0.968	0.880	2.133	0.779	0.825	0.867	0.685
	SI2	3.593	0.979	0.849	1.466				
	SI3	3.579	0.959	0.748	1.748				

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TABLE 3 Discriminant validity—Fornell Larcker.

Construct	(BI)	(EE)	(IUG)	(LE)	(LM)	(LDL)	(PE)	(SI)
Behavioral intention (BI)	0.902							
Effort expectancy (EE)	0.763	0.867						
Intention to use gamification in learning (IUG)	0.789	0.721	0.887					
Learning enjoyment (LE)	0.730	0.789	0.759	0.907				
Learning motivation (LM)	0.791	0.673	0.798	0.767	0.903			
Level of digital literacy (LDL)	0.700	0.790	0.631	0.673	0.583	0.927		
Performance expectancy (PE)	0.795	0.808	0.773	0.744	0.780	0.657	0.913	
Social influence (SI)	0.637	0.614	0.569	0.588	0.512	0.510	0.642	0.828

TABLE 4 The findings from the Bootstrapping procedure—path coefficient.

Hypothesis	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	*P*-values
H1: performance expectancy (PE) -> learning motivation (LM)	0.674	0.667	0.109	6.190	<0.001
H2: effort expectancy (EE) -> learning motivation (LM)	0.048	0.051	0.112	0.430	0.667
H3: effort expectancy (EE) -> learning enjoyment (LE)	0.399	0.399	0.092	4.362	<0.001
H4: social influence (SI) -> learning enjoyment (LE)	0.099	0.102	0.045	2.183	0.029
H5: level of digital literacy (LDL) -> learning motivation (LM)	0.102	0.110	0.089	1.140	0.254
H6: level of digital literacy (LDL) -> learning enjoyment (LE)	0.070	0.064	0.084	0.826	0.409
H7: learning motivation (LM) -> learning enjoyment (LE)	0.407	0.409	0.091	4.474	<0.001
H8: learning motivation (LM) -> behavioral intention (BI)	0.562	0.556	0.092	6.123	<0.001
H9: learning enjoyment (LE) -> behavioral intention (BI)	0.299	0.305	0.082	3.636	<0.001
H10: behavioral intention (bi) -> intention to use gamification in learning (IUG)	0.789	0.789	0.044	18.060	<0.001

enjoyed gamified activities, the stronger their intention to engage with them.

The indirect effect of Effort Expectancy on Behavioral Intention through Learning Enjoyment is significant ($\beta = 0.094$, $p < 0.001$), indicating that, even though Effort Expectancy does not directly influence Learning Motivation, it does contribute to Behavioral Intention indirectly through Learning Enjoyment. This underlines the importance of enjoyment as a mechanism by which students' ease-of-use perceptions translate into behavioral intentions.

3.5 Model fit and R^2

Table 6 presents the model fit indices, which indicate that the proposed model has an acceptable fit with the data. The Standardized Root Mean Square Residual (SRMR) is 0.058 for the saturated model, which is below the threshold of 0.08, indicating a good fit (Hu and Bentler, 1999; Henseler et al., 2016). The R^2 values show that the model explained 66.3% of the variance in Behavioral Intention and 62.2% of the variance in Intention to Use Gamification, demonstrating substantial explanatory power (Chin, 1998).

Figure 3 illustrates the final model, which provides a visual representation of the significant relationships between constructs. The path from Performance Expectancy to Learning Motivation, and subsequently to Behavioral Intention and Intention to Use Gamification, is particularly notable for its strength ($\beta = 0.674$ for Performance Expectancy to Learning Motivation; $\beta = 0.789$ for behavioral intention to use gamification). These paths underscore the critical role of motivation in shaping students' intention to adopt gamification in STEM education. Conversely, weaker relationships, such as that between Effort Expectancy and Learning Motivation, highlight areas where ease of use alone does not significantly impact engagement without other factors, such as

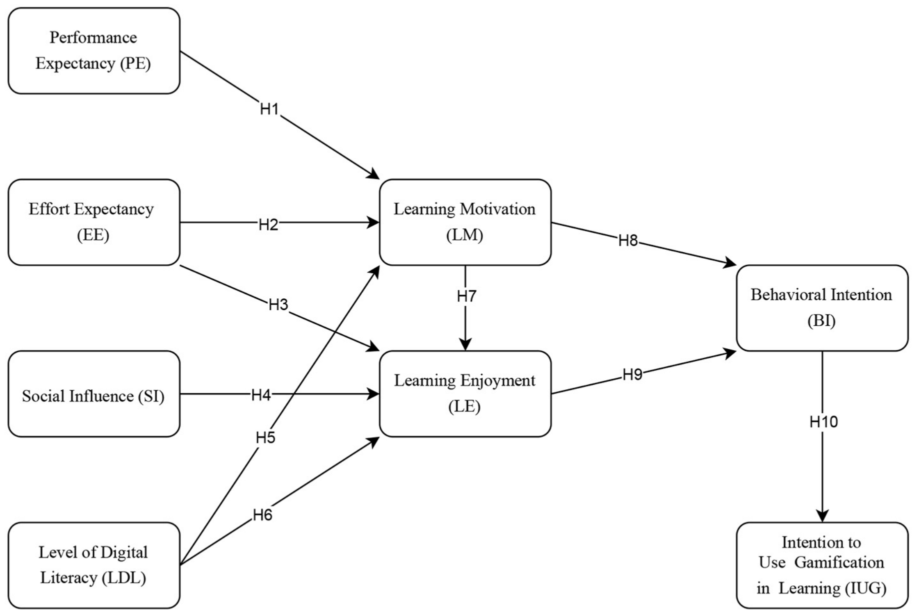

FIGURE 2
Conceptual framework of the proposed UTAUT model.

enjoyment or social influence. The model highlights that students' behavioral intention to use gamification is largely driven by how much they enjoy and are motivated by gamified learning activities.

The results of our study highlight that the most significant factor influencing students' Behavioral Intention to use gamification in STEM education is Learning Motivation, followed by Learning Enjoyment. Specifically, the direct effect of Learning Motivation on Behavioral Intention ($\beta = 0.562$, $p < 0.001$) indicates that students who are highly motivated to engage in learning are more likely to develop a strong intention to use gamified tools. This suggests that fostering intrinsic motivation through gamification is crucial for driving students' willingness to adopt such technologies. Additionally, Behavioral Intention strongly predicts the Intention to Use Gamification ($\beta = 0.789$, $p < 0.001$), underscoring the pivotal role of students' pre-existing intentions in actual technology adoption. Moreover, Performance Expectancy indirectly influences the Intention to Use Gamification through its significant effect on Learning Motivation, emphasizing the importance of students' beliefs in gamification's utility for improving their academic performance. While Effort Expectancy and Social Influence play smaller but significant roles, it is clear that enjoyment and motivational aspects of learning have the most substantial impact on whether students intend to use gamification in their STEM courses.

4 Discussion

4.1 The importance of adopting gamification in learning mathematics

The integration of game elements and principles into education has literally emerged as a game-changer. This approach, known as gamification, has shown remarkable capabilities in transforming how students engage with and learn mathematical concepts. This study, along with a growing body of studies in educational research, suggests that gamification tools could be a key to unlocking a new era of mathematics education. That is, to improve student engagement, enhance motivation, and boost academic performance (Nand et al., 2019; Rodriguez and Cusme, 2023; Rincon-Flores et al., 2023). By blending elements of play into learning, such as rewards systems, progressive difficulty levels, and visually engaging presentations, educators were able to observe reduced anxiety and improved attitudes toward mathematics—with newfound enthusiasm and confidence (Chen et al., 2023; Rincon-Flores et al., 2023).

Some investigations have reported mixed outcomes in relation to learning gains (see, for example, Chen et al., 2023), however, a comprehensive meta-analysis encompassing 30 interventions revealed a notable medium effect size that favors gamified approaches over conventional teaching methods (Bai et al., 2020). This gamified-led strategy not only enhances students' grasp of mathematical principles but also nurtures an intrinsic drive to learn (Alkandari et al., 2021; Al-Shamali et al., 2022; Alkandari, 2023). Evidence consistently points to gamification's positive impact on factors such as student motivation, engagement, and academic performance.

Gamification is shown to develop skills that extend far beyond the classroom: problem-solving, perseverance, and self-regulation are not just valuable in mathematics; they are also essential life skills. Across various academic disciplines, research has also shown improvements in attendance, engagement with course materials, and overall course grades (Ibanez et al., 2014; Fotaris et al., 2016). In addition to, fostering enthusiasm, providing timely performance feedback, and encouraging goal-setting behaviors (Bai et al., 2020). Gamified tools cultivate skills essential for 21st-century

TABLE 5 The indirect effects and the mediated effects of performance expectancy on effort expectancy-intentions to use Gamification in Learning.

Hypothesis	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	*P* values
Learning motivation (LM) -> Behavioral intention (BI) -> Intention to use gamification in learning (IUG)	0.444	0.439	0.080	5.533	<0.001
Performance expectancy (PE) -> Learning motivation (LM) -> Behavioral intention (BI) -> Intention to use gamification in learning (IUG)	0.299	0.295	0.077	3.864	<0.001
Learning enjoyment (LE) -> Behavioral intention (BI) -> Intention to use gamification in learning (IUG)	0.236	0.241	0.067	3.510	<0.001
Effort expectancy (EE) -> Learning enjoyment (LE) -> Behavioral intention (BI) -> Intention to use gamification in learning (IUG)	0.094	0.094	0.029	3.200	<0.001
Performance expectancy (PE) -> Learning motivation (LM) -> Learning enjoyment (LE) -> Behavioral intention (BI) -> Intention to use gamification in learning (IUG)	0.065	0.066	0.027	2.383	0.017
Learning motivation (LM) -> Learning enjoyment (LE) -> Behavioral intention (BI) -> Intention to use gamification in learning (IUG)	0.096	0.101	0.043	2.229	0.026
Social influence (SI) -> Learning enjoyment (LE) -> Behavioral intention (BI) -> Intention to use gamification in learning (IUG)	0.023	0.025	0.014	1.721	0.085
Level of digital literacy (LDL) -> Learning motivation (LM) -> Behavioral intention (BI) -> Intention to use gamification in learning (IUG)	0.045	0.048	0.040	1.128	0.259
Level of digital literacy (LDL) -> Learning motivation (LM) -> Learning enjoyment (LE) -> Behavioral intention (BI) -> Intention to use gamification in learning (IUG)	0.010	0.012	0.012	0.804	0.421
Level of digital literacy (LDL) -> Learning enjoyment (LE) -> Behavioral intention (BI) -> Intention to use gamification in learning (IUG)	0.016	0.015	0.021	0.791	0.429
Effort expectancy (EE) -> Learning motivation (LM) -> Behavioral intention (BI) -> Intention to use gamification in learning (IUG)	0.021	0.022	0.050	0.430	0.668
Effort expectancy (EE) -> Learning motivation (LM) -> Learning enjoyment (LE) -> Behavioral intention (BI) -> Intention to use gamification in learning (IUG)	0.005	0.006	0.013	0.350	0.727

professionals without compromising academic standards (Murillo-Zamorano et al., 2021).

The validation of the extended UTAUT model within a gamified STEM learning context provides important insights for educators and curriculum designers. Notably, learning motivation emerged as the strongest predictor of students' behavioral intention to adopt gamified tools ($\beta = 0.562$, $p < 0.001$), underscoring the pivotal role of intrinsic motivation in shaping technology adoption. Educators should therefore prioritize the design of gamified learning experiences that not only align with academic objectives but also enhance motivational elements—such as achievement, enjoyment, and relevance. By leveraging gamification to stimulate students' motivation, instructors can foster deeper engagement and support sustained use of technology in STEM education.

It is important to highlight that some studies have identified potential drawbacks, such as diminished self-regulated learning processes in certain contexts (Opriş et al., 2024). Nonetheless, gamification has generally been observed to increase students' willingness to participate in class discussions, dedicate time to study, and learn from their mistakes (Hellín et al., 2023).

The effectiveness of gamification may vary based on individual personality traits and motivational orientations, whether intrinsic or extrinsic (AlReshaid et al., 2025; Smiderle et al., 2020).

For the current generation of digital natives, whom are accustomed to interactive and immersive technologies, gamification offers a familiar and engaging approach to complex academic content, thereby enhancing their overall learning outcomes. In the realm of mathematics education, gamification proves particularly effective by transforming static exercise into dynamic learning experiences. Students are more inclined to engage with mathematical concepts when presented in a game-like format. This alleviates the anxiety often associated with the subject and facilitates repeated practice in a low-pressure environment. This pedagogical shift aligns with broader educational trends—emphasizing creativity and innovation in the classroom, and preparing students for the demands of an evolving technological landscape.

TABLE 6 Model fit and R^2.

Overall Model Metric	Saturated model	Estimated model
SRMR	0.058	0.100
d_ULS	0.997	3.007
d_G	0.768	0.936
Chi-square	667.719	750.757
NFI	0.800	0.775
Construct	R-square	R-square adjusted
Behavioral Intention (BI)	0.663	0.658
Intention to Use Gamification in Learning (IUG)	0.622	0.620
Learning Enjoyment (LE)	0.732	0.724
Learning Motivation (LM)	0.617	0.609

4.2 Key factors influencing intention to use gamification in learning

This investigation on the effectiveness of gamification in learning highlights several critical factors that influence the inclination of students to embrace gamification in their learning journey. Notably, performance expectancy—student's belief that gamification will enhance their academic performance—emerged as a significant predictor of their intention to utilize gamified learning tools. This particular finding resonates with the broader literature on technology acceptance, underscoring the importance of perceived usefulness in motivating students to engage with novel educational technologies (García-López et al., 2023; Jaramillo-Mediavilla et al., 2024; Othman et al., 2023; Zeng et al., 2024). Once students perceive a direct link between gamification and improved academic outcomes, they are more likely to invest more time and efforts in these tools. This aligns with previous studies that emphasize technology's role in boosting academic performance through increased engagement and motivation (Ratinho and Martins, 2023).

Learning motivation emerges as another crucial factor that influences the adoption of gamification. By tapping into both intrinsic and extrinsic motivators, gamification plays a vital role

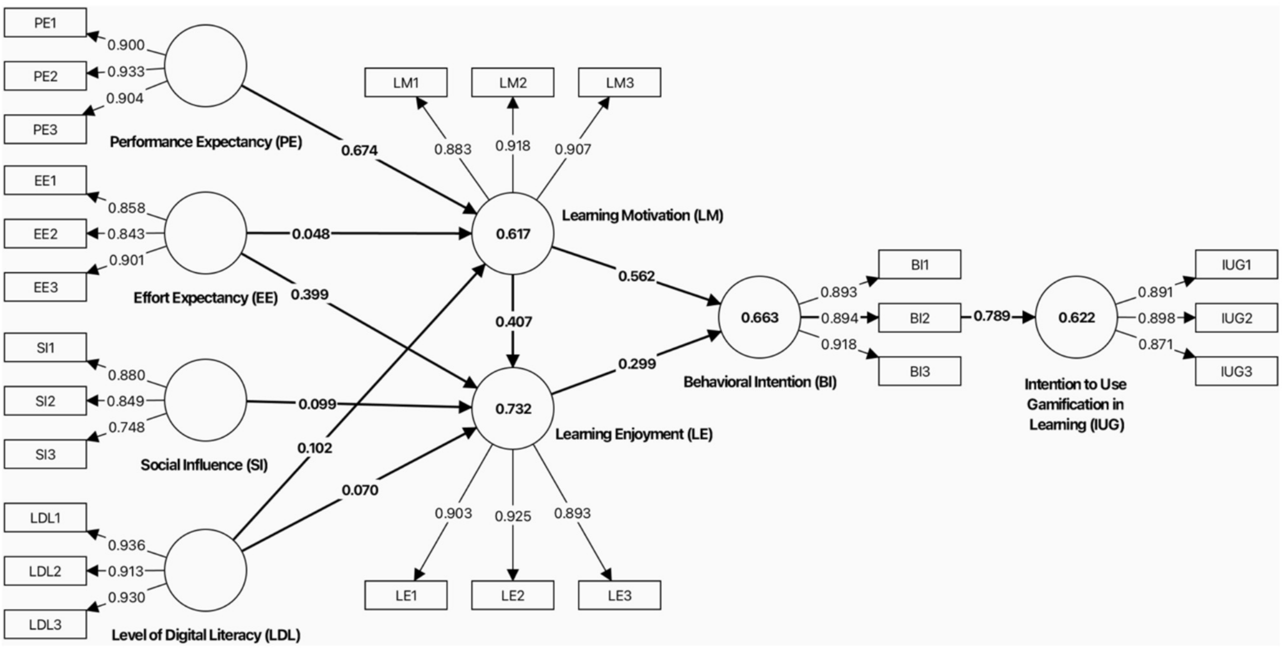

FIGURE 3
An illustration of the results from SEM-PLS algorithm.

in sustaining student engagement over time. In the literature, it has been demonstrated that gamified learning environments are a key component for enhancing students' intrinsic motivation by providing immediate feedback and a sense of accomplishment (Al-Shamali et al., 2022; Ratinho and Martins, 2023). As students find joy in the learning process, it is more likely they remain committed to their academic goals, supporting the notion that enjoyment derived from gamification is a critical driver of educational success.

Social influence is another factor that plays a significant role in students' adoption of gamification. Instructor encouragement and peer interactions are key contributors to creating a supportive learning environment, where students feel motivated to participate. Research suggests that social dynamics, that is, collaboration and competition, within a gamified framework can enhance student engagement and foster a cohesive learning community (Chung and Pan, 2023; Vanduhe et al., 2020; Xu et al., 2017). Students are more likely to embrace educational technologies when they perceive that their peers and instructors value and support these tools (Alkandari et al., 2024; Magano et al., 2020). Promoting a positive social environment around gamification is essential to encourage widespread adoption among students (Vanduhe et al., 2020).

4.3 Limitations and future directions

While the findings are promising, it is necessary to acknowledge the limitations of our current study. Using convenience sampling may restrict the generalizability of the results (Alqatan et al., 2025). Our sample was drawn from a specific university setting and was limited to mathematics courses. Thus, the sample may not be representative of the broader student population across different academic disciplines or educational levels. Such limitation is common in educational research, where access to diverse samples can be challenging. Furthermore, the cross-sectional nature of our investigation prevents us from examining the evolution of students' attitudes toward gamification in time as they gain more experience with these tools. Longitudinal research could provide a more comprehensive understanding of gamification's long-term impact on learning outcomes.

Although the inclusion of digital literacy (LDL) in the proposed model was theoretically justified, the findings revealed that its effects on both learning motivation (H5) and learning enjoyment (H6) were statistically non-significant. One possible explanation is that the surveyed participants, predominantly undergraduate students from private universities in Kuwait, may already possess a high baseline level of digital literacy due to their status as digital natives. As such, variations in LDL may not have played a distinguishing role in shaping their engagement with gamified learning tools. Future research could benefit from exploring this construct in more digitally diverse populations or including more nuanced measures of digital competency to capture differences in how students interact with gamified systems.

Our exclusive focus on quantitative data is another limitation of the study. While our survey provided valuable insights into students' attitudes and intentions, qualitative data could offer a deeper insight into their gamification experiences. Conducting interviews or focus groups would allow for the exploration of students' personal narratives and provide richer contextual data. Lastly, our results were based solely on mathematics courses, which may limit its applicability to other subjects. Further research should investigate whether the factors influencing gamification adoption in mathematics are consistent across other STEM disciplines.

Building on our findings, future studies should explore the long-term effects of gamification on learning outcomes across a broader range of academic disciplines. Longitudinal studies would be particularly beneficial in examining how sustained exposure to gamification influences students' engagement, motivation, and academic performance over time. In addition, future investigations should incorporate more diverse student populations to enhance the generalizability of findings. Various educational backgrounds, disciplines, and academic achievement levels should be included to gain a more nuanced understanding of how gamification functions in different educational settings.

Interviews and/or focus groups should be incorporated into future studies as part of the qualitative methods to capture students' personal experiences with gamification. Such research methods would provide a deeper understanding of the specific elements of gamified learning environments that students find most motivating and effective. Moreover, exploring the impact of individual differences, such as personality traits or learning styles, on students' responsiveness to gamification would help educators design more personalized and effective gamified interventions.

4.4 Practical recommendations

In light of our findings, educators are recommended to focus on creating gamified learning environments, not only to enhance academic performance, but to foster enjoyment and intrinsic motivation. By designing activities that are both challenging and rewarding, educators can tap into students' natural desire for achievement and growth. The social aspects of gamification should not be overlooked; encouraging collaboration and healthy competition among students can create a more dynamic and engaging learning environment, further enhancing the effectiveness of gamified learning tools.

5 Conclusion

This study highlights the significant role of gamification in enhancing the effectiveness of mathematics education. Key factors such as performance expectancy, learning motivation, and social influence were found to be crucial in shaping students' behavioral intentions to adopt gamified learning tools. By integrating game elements that foster both academic achievement and enjoyment, gamification offers a dynamic and engaging approach to learning, motivates students, and promotes deeper engagement with educational content. This approach not only enhances performance but also creates a more interactive and enjoyable learning experience for students, potentially revolutionizing the landscape of mathematics education.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Institutional Review Board (IRB) of Kuwait Technical College. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

AbA: Investigation, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing. AhA: Data curation, Formal analysis, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. CE: Data curation, Investigation, Resources, Validation, Writing – review & editing. AnA: Investigation, Resources, Validation, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2025.1586466/full#supplementary-material

References

Abbad, M. (2021). Using the UTAUT model to understand students' usage of e-learning syst ems in developing countries. *Educ. Inform. Technol.* 26, 7205–7224. doi: 10.1007/s10639-021-10573-5

Abdulla, H. (2022). Instructional design strategies for using Gamification in E-learning: a case study. *Int. Design J.* 3, 31–38. doi: 10.21608/idj.2022.149053.1050

Ahmed, S., Zeeshan, M., Parsons, D., Rehman, O., Ahmed, Z., Ahmad, A., et al. (2025). Exploring game-based inquiry learning application in a maritime science museum: a visitors' perspective. *Hum. Behav. Emerg. Technol.* 2025:8284489. doi: 10.1155/hbe2/8284489

Alkandari, A., Alseddiqi, A., and Alsaber, A. A. R. (2021). Measuring instructor's readiness on accepting the use of e-learning system during COVID-19 pandemic in higher education of Kuwait. *J. Acad. Business Econ.* 21, 29–40. doi: 10.18374/JABE-21-2.3

Alkandari, F., Alsaber, A., Al-Kandari, A., Alboloushi, B., and AlMutairi, S. (2024). Enhancing the effectiveness of digital transformation on teaching in higher education in Kuwait. *Front. Educ.* 9:1417062. doi: 10.3389/feduc.2024.1417062

Alkandari, K. (2023). Transformation to competency-based curriculum: readiness and self-efficacy among Islamic studies teachers in Kuwait. *Curric. Perspect.* 43, 67–79. doi: 10.1007/s41297-022-00179-3

Al-Kenane, K., Almoraish, A., Al-Enezi, D., Al-Matrouk, A., AlBuloushi, N., and Alreshaid, F. (2025). The process through which young adults form attitudes towards sustainable products through social media exposure in Kuwait. *Sustainability* 17:4442. doi: 10.3390/su17104442

Alqatan, A., Simmou, W., Shehadeh, M., AlReshaid, F., Elmarzouky, M., and Shohaieb, D. (2025). Strategic pathways to corporate sustainability: the roles of transformational leadership, knowledge sharing, and innovation. *Sustainability* 17:5547. doi: 10.3390/su17125547

AlReshaid, F., Erturk, A., Alkhayyat, R., Abdallah, F., Abidi, O., and De La Roche, M. (2025). Are we on the same wavelength? Supervisor-subordinate cognitive style congruence and its association with supervisors' self-awareness through leader member exchange. *Front. Psychol.* 16:1583837. doi: 10.3389/fpsyg.2025.1583837

Al-Shamali, S., Al-Shamali, A., Alsaber, A., Al-Kandari, A., AlMutairi, S., and Alaya, A. (2022). Impact of organizational culture on academics' readiness and behavioral intention to implement elearning changes in Kuwaiti universities during COVID-19. *Sustainability* 14:15824. doi: 10.3390/su142315824

Alshammari, M., Salifu, Y., Alwadaany, B., Ladan, M. A., Abdul, H. M., Alsaber, A., et al. (2025). E-learning adoption in nursing education: feasibility analysis using the technology acceptance model with a focus on digital and information literacy. *Front. Educ.* 10:1632298. doi: 10.3389/feduc.2025.1632298

Anaktototy, K. (2023). Promoting creativity and innovation in the teaching and learning process. *Educ. Sci. J.* 4, 59–66. doi: 10.30598/edusciencesvol4iss1pp59-66

Bai, S., Hew, K. F., and Huang, B. (2020). Does gamification improve student learning outcome? Evidence from a me ta-analysis and synthesis of qualitative data in educational contexts. *Educ. Res. Rev.* 30:100322. doi: 10.1016/j.edurev.2020.100322

Bervell, B., and Umar, I. (2017). Validation of the UTAUT model: re-considering non-linear relationships of exogeneous variables in higher education technology acceptance research. *Eurasia J. Math. Sci. Technol. Educ.* 13, 6471–6490. doi: 10.12973/ejmste/78076

Birch, A., and Irvine, V. (2009). Preservice teachers' acceptance of ICT integration in the classroom: a pplying the UTAUT model. *EMI. Educ. Media Int.* 46, 295–315. doi: 10.1080/09523980903387506

Bouchrika, I., Harrati, N., Wanick, V., and Wills, G. (2019). Exploring the impact of gamification on student engagement and involve ment with e-learning systems. *Interact. Learn. Environ.* 29, 1244–1257. doi: 10.1080/10494820.2019.1623267

Boulesteix, A., and Strimmer, K. (2007). Partial least squares: a versatile tool for the analysis of high-dimensional genomic data. *Brief. Bioinformatics* 8, 32–44. doi: 10.1093/bib/bbl016

Buckley, P., and Doyle, E. (2016). Gamification and student motivation. *Interact. Learn. Environ.* 24, 1162–1175 doi: 10.1080/10494820.2014.964263

Chao, C. (2019). Factors determining the behavioral intention to use mobile learning: an application and extension of the UTAUT model. *Front. Psychol.* 10:1652. doi: 10.3389/fpsyg.2019.01652

Chen, M.-F., Chen, Y.-C., Zuo, P.-Y., and Hou, H.-T. (2023). Design and evaluation of a remote synchronous gamified mathematics tea ching activity that integrates multi-representational scaffolding and a mind tool for gamified learning. *Educ. Inform. Technol.* 28, 13207–13233. doi: 10.1007/s10639-023-11708-6

Chin, W. W. (1998). "The partial least squares approach to structural equation modeling," in *Modern Methods for Business Research* (Psychology Press), 295–336.

Chitra, K. (2020). Adoption of gamification tool in higher education: an empirical study. *Stud. Indian Place Names* 40, 3132–3146.

Christopoulos, A., and Mystakidis, S. (2023). Gamification in education. *Encyclopedia* 3, 1223–1243. doi: 10.3390/encyclopedia3040089

Chung, C.-H., and Pan, H.-L. W. (2023). Assessing the effects of flow, social interaction, and engagement on students' gamified learning: a mediation analysis. *Sustainability* 15:983. doi: 10.3390/su15020983

Dawo, J. I., and Sika, J. (2021). Higher education in evolving world: accelerating the pace of change in teaching for learning. *Eur. J. Educ. Stud.* 8, 223–236. doi: 10.46827/ejes.v8i12.4029

Denden, M., Tlili, A., Chen, N., Abed, M., Jemni, M., and Essalmi, F. (2022). Role of learners' characteristics in educational gamification systems: a systematic meta-review of the literature. *Interact. Learn. Environ.* 32, 790–812 doi: 10.1080/10494820.2022.2098777

Dichev, C., and Dicheva, D. (2017). Gamifying education: what is known, what is believed and what remains uncertain: a critical review. *Int. J. Educ. Technol. High. Educ.* 14:9. doi: 10.1186/s41239-017-0042-5

Diño, M. J., and Guzman, A. (2015). Using partial least squares (PLS) in predicting behavioral intention f or telehealth use among filipino elderly. *Educ. Gerontol.* 41, 53–68. doi: 10.1080/03601277.2014.917236

Fatima, A., Shaheen, A., Ahmed, S., Fazal, B., Ahmad, F., Liew, T., et al. (2024). Exploring the use of gamification in human-centered agile-based requirements engineering. *Front. Comput. Sci.* 6:1442081. doi: 10.3389/fcomp.2024.1442081

Figg, C., and Jaipal-Jamani, K. (2018). "Developing teacher knowledge about gamification as an instructional strategy," in *Teacher Training and Professional Development: Concepts, Methodologies, Tools, and Applications* (IGI Global Scientific Publishing), 1215–1243.

Fornell, C., and Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement errors *J. Market. Res.* 18, 39–50. doi: 10.1177/002224378101800104

Fotaris, P., Mastoras, T., Leinfellner, R., and Rosunally, Y. (2016). Climbing up the leaderboard: An empirical study of applying Gamification techniques to a computer programming class. *Electr. J. e-Learn.* 14, 95–110

Gamarra, M., Dominguez, A., Velazquez, J., and Páez, H. (2021). A gamification strategy in engineering education—a case study on motivation and engagement. *Comput. Applic. Eng. Educ.* 30, 472–482. doi: 10.1002/cae.22466

García-López, I. M., Acosta-Gonzaga, E., and Ruiz-Ledesma, E. F. (2023). Investigating the impact of gamification on student motivation, engagement, and performance. *Educ. Sci.* 13:813. doi: 10.3390/educsci13080813

Graber, M. L. (2009). Educational strategies to reduce diagnostic error: can you teach this stuff? *Adv. Health Sci. Educ.* 14(Suppl 1), 63–69. doi: 10.1007/s10459-009-9178-y

Hair, J., Hollingsworth, C., Randolph, A. B., and Chong, A. Y. L. (2017). Updated and expanded assessment of PLS-SEM in information systems research. *Indus. Manag. Data Syst.* 117, 442–458. doi: 10.1108/IMDS-04-2016-0130

Hair, J., Sarstedt, M., Hopkins, L., and Kuppelwieser, V. (2014). Partial least squares structural equation modeling (PLS-SEM): an emerging tool in business research. *Eur. Business Rev.* 26, 106–121. doi: 10.1108/EBR-10-2013-0128

Ham, F. M., and Kostanic, I. (1996). Partial least squares: theoretical issues and engineering applications in signal processing. *Math. Probl. Eng.* 2, 63–93. doi: 10.1155/S1024123X96000245

Harris, K. C., and Redlo, J. M. (2021). "Emergence of digitized gamification as an educational tool and the implications on digital literacy and equity," in *AIJR Proceedings*, 364–368.

Hellín, C. J., Calles-Esteban, F., Valledor, A., Gómez, J., Otón-Tortosa, S., and Tayebi, A. (2023). Enhancing student motivation and engagement through a gamified learning environment. *Sustainability* 15:14119. doi: 10.3390/su151914119

Henseler, J., Hubona, G., and Ray, P. A. (2016). Using PLS path modeling in new technology research: updated guidelines. *Indus. Manag. Data Syst.* 116, 2–20. doi: 10.1108/IMDS-09-2015-0382

Hu, L., and Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Struct. Equat. Model. Multidiscipl. J.* 6, 1–55. doi: 10.1080/10705519909540118

Ibanez, M.-B., Di-Serio, A., and Delgado-Kloos, C. (2014). Gamification for engaging computer science students in learning activities: a Case Study. *IEEE Trans. Learn. Technol.* 7, 291–301. doi: 10.1109/TLT.2014.2329293

Jang, J., Park, J., and Yi, M. (2015). "Gamification of online learning, in *Artificial Intelligence in Education. AIED 2015. Lecture Notes in Computer Science()*, eds. C. Conati, N. Heffernan, A. Mitrovic, and M. Verdejo (Cham: Springer), 646–649. doi: 10.1007/978-3-319-19773-9_82

Jaramillo-Mediavilla, L., Basantes-Andrade, A., Cabezas-González, M., and Casillas-Martín, S. (2024). Impact of gamification on motivation and academic performance: a systematic review. *Educ. Sci.* 14:639. doi: 10.3390/educsci140 60639

Jiang, H. W., and Xia, J. L. (2003). Partial least square and its application. *J. Fourth Mil. Med. Univ.* 21, 280–283.

Juliansyach, R. P., and Christiarini, R. (2024). Analisa behavioural intention dan use behaviour pada aplikasi game online berbasis mobile phone menggunakan metode UTAUT2. *J. Manaj. Strategi Apl. Bisnis* 7, 271–290. doi: 10.36407/jmsab.v7i2.1154

Kalogiannakis, M., Papadakis, S., and Zourmpakis, A.-I. (2021). Gamification in science education. A systematic review of the literature. *Educ. Sci.* 11:22. doi: 10.3390/educsci11010022

Kijsanayotin, B., Pannarunothai, S., and Speedie, S. M. (2009). Factors influencing health information technology adoption in Thailand's community health centers: applying the UTAUT model. *Int. J. Med. Inform.* 78, 404–416. doi: 10.1016/j.ijmedinf.2008.12.005

Kiryakova, G., Angelova, N., and Yordanova, L. (2014). "Gamification in education," in *Proceedings of 9th International Balkan Education and Science Conference, Vol. 1*, 679–684.

Kumar, K. (2021). Partial least squares (PLS) analysis. *Resonance* 26, 429–442. doi: 10.1007/s12045-021-1140-1

Lee, L., Petter, S., Fayard, D., and Robinson, S. (2011). Partial least squares path modeling in accounting research. *Int. J. Account. Inform. Syst.* 12, 305–328. doi: 10.1016/j.accinf.2011.05.002

Li, M., Ma, S., and Shi, Y. (2023). Examining the effectiveness of gamification as a tool to promote teaching and learning in educational settings: a meta-analysis. *Front. Psychol.* 14:1253549. doi: 10.3389/fpsyg.2023.1253549

Magano, J., Alves, M., Durão, R., and de Carvalho, C. V. (2020). Adoption and use of educational technology tools by marketing students. *Electr. J. E-Learn.* 18, 347–356. doi: 10.34190/EJEL.20.18.4.007

Manurung, K., and Tadulako, U. (2012). Creative teachers and effective teaching strategies that motivate learners to learn. *Indones. J. Sci. Educ.* 2, 1–8.

Manzano-León, A., Camacho-Lazarraga, P., Guerrero, M. A., Guerrero-Puerta, L., Aguilar-Parra, J. M., Trigueros, R., et al. (2021). Between level up and game over: a systematic literature review of the gami classification in education. *Sustainability* 13:2247. doi: 10.3390/su13042247

Mohzan, M. A. M., and Zubir, H. A. (2019). Teaching the Millennials: implications on today's classrooms. *Univ. J. Educ. Res.* 7, 186–191. doi: 10.13189/ujer.2019.0 71622

Mokhtar, F. A. (2016). Rethinking conventional teaching in language learning and proposing Edmodo as intervention: a qualitative analysis. *Malaysian Online J. Educ. Technol.* 4, 22–37.

Mokhtari, F. (2023). Fostering digital literacy in higher education: benefits, challenges and implications. *Int. J. Linguist. Liter. Transl.* 6, 160–167. doi: 10.32996/ijllt.2023.6.10.19

Murillo-Zamorano, L. R., Sánchez, J. Á., Godoy-Caballero, A. L., and Muñoz, C. (2021). Gamification and active learning in higher education: is it possible to match the interests of digital society, academia, and students? *Int. J. Educ. Technol. High. Educ.* 18:15. doi: 10.1186/s41239-021-00249-y

Nägle, S., and Schmidt, L. (2012). Computer acceptance of older adults. *Work* 41, 3541–3548. doi: 10.3233/WOR-2012-0633-3541

Nand, K., Baghaei, N., Casey, J., Barmada, B., Mehdipour, F., and Liang, H.-N. (2019). Engaging children in educational content via gamification. *Smart Learn. Environ.* 6, 1–15 doi: 10.1186/s40561-019-0085-2

Nurtanto, M., Kholifah, N., Ahdhianto, E., Samsudin, A., and Isnantyo, F. (2021). A review of gamification impact on student behavioral and learning outcomes. *Int. J. Interact. Mobile Technol.* 15, 22–36. doi: 10.3991/ijim.v15i21.24381

Oliveira, L. C., de, Pinochet, L. H. C., Bueno, R. L. P., and Oliveira, M. A., de. (2019). Efeito da gamificação na intenção de uso de treinamentos on-line: uma adaptação do modelo UTAUT aplicado no TRT-2. *Rev. Administr. UFSM* 12, 472–491. doi: 10.5902/1983465921624

Opriş, E. T., Zsoldos-Marchis, I., and Egri, E. (2024). Impact of gamified problem sheets in Seppo on self-regulation skills. *Open Educ. Stud.* 6:20240024. doi: 10.1515/edu-2024-0024

Othman, N. A. F., Jaini, A., Ismail, M., Zainoddin, A. I., Mohamad Radzi, S. F., and Sundram, V. P. (2023). Gamification in online learning: a case study of university students in Malaysia. *Asian J. Univ. Educ.* 19, 282–293. doi: 10.24191/ajue.v19i2.22239

Pirouz, D. M. (2006). *An Overview of Partial Least Squares*. Available online at: http://ssrn.com/abstract=1631359 (Accessed February 26, 2024).

Qendraj, D., Xhafaj, E., and Thanasi, T. (2022). A hybridized approach of PLS-SEM and fuzzy Z-AHP to evaluate the UTAUT 2 model for an LMS. *J. Intell. Fuzzy Syst.* 43, 1–13. doi: 10.3233/JIFS-212396

Ratinho, E., and Martins, C. (2023). Role of gamified learning strategies in students' motivation in high school and higher education: a systematic review. *Heliyon* 9:e19033. doi: 10.1016/j.heliyon.2023.e19033

Rincon-Flores, E. G., Santos-Guevara, B. N., Martinez-Cardiel, L., Rodriguez-Rodriguez, N. K., Quintana-Cruz, H. A., and Matsuura-Sonoda, A. (2023). Gamit! Icing on the cake for mathematical gamification. *Sustainability* 15:2334. doi: 10.3390/su15032334

Rodriguez, R., and Cusme, K. (2023). Use of gamification as a pedagogical strategy to strengthen the unders tanding of application problems with rational numbers. *Minerva* 2023, 64–73. doi: 10.47460/minerva.v2023iSpecial.118

Sanmugam, M., Mohd Zaid, N., Mohamed, H., Abdullah, Z., Aris, B., and Md Suhadi, S. (2015). Gamification as an educational technology tool in engaging and motivating students: an analysis review. *Adv. Sci. Lett.* 21, 3337–3341. doi: 10.1166/asl.2015.6489

Smiderle, R., Rigo, S. J., Marques, L. B., Peçanha de Miranda Coelho, J. A., and Jaques, P. A. (2020). The impact of gamification on students' learning, engagement, and behavior based on personality traits. *Smart Learn. Environ*. 7:3. doi: 10.1186/s40561-019-0098-x

Taylor, T. (2014). Changing pedagogy for modern learners: lessons from an educator's journey of self-reflection. *J. Educ. Tech. Soc.* 17, 79–88.

Thurston, T. (2018). Design case: implementing gamification with ARCS to engage digital natives. *J. Empower. Teach. Excell. J. Empower. Teach. Excell*. 2, 23–52.

Van, V. (2020). Identify methods of teaching and learning to create interest, self-study, and creativity of students. *Human. Soc. Sci. Rev.* 8, 646–656 doi: 10.18510/hssr.2020.8369

Vanduhe, V. Z., Nat, M., and Hasan, H. F. (2020). Continuance intentions to use gamification for training in higher educ ation: integrating the technology acceptance model (TAM), social motiv ation, and task technology fit (TTF). *IEEE Access* 8, 21473–21484. doi: 10.1109/ACCESS.2020.2966179

Venkatesh, V., Morris, M. G., Davis, G. B., and Davis, F. D. (2003). User acceptance of information technology: toward a unified view. *MIS Quart*. 27, 425–478. doi: 10.2307/30036540

Wills, M. J., and El-Gayar, O. (2008). Examining healthcare professionals' acceptance of electronic medical r ecords using utaut. *Issues Inform. Syst*. 9, 396–401.

Wulan, D., Nainggolan, D., Hidayat, Y., Rohman, T., and Fiyul, A. (2024). Exploring the benefits and challenges of gamification in enhancing student learning outcomees. *Glob. Int. J. Innov. Res.* 2, 1657–1674. doi: 10.59613/global.v2i7.238

Xu, H., Song, D., and Ju, P. (2017). Engaged cohorts: can gamification engage all college students in class ? *Eurasia J. Math. Sci. Technol. Educ.* 13, 3723–3734. doi: 10.12973/eurasia.2017.00755a

Yang, K. (2010). Determinants of US consumer mobile shopping service adoption: implications for designing mobile shopping services. *J. Cons. Market.* 27, 262–270. doi: 10.1108/07363761011038338

Yushaa, S. M., Mazlina, S., Khuzzan, S., and Hanid, M. (2021). Gamification elements and its impact on students. *J. Technol. Operat. Manag.*16, 62–75.

Zeng, J., Sun, D., Looi, C. K., and Fan, A. C. W. (2024). Exploring the impact of gamification on students' academic performance: a comprehensive meta-analysis of studies from the year 2008 to 2023. *Br. J. Educ. Technol*. 55, 2478–2502.

Zeybek, N., and Saygi, E. (2023). Gamification in education: why, where, when, and how?A systematic review. *Games Cult.* 19, 237–264. doi: 10.1177/155541202311 58625