The relationship between perceived gamified learning support, students' motivation, affective engagement, and self-efficacy: A structural equation modelling approach

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Abstract. The integration of gamification tools such as Quizizz and Kahoot! into formative assessment and learning support has attracted growing interest among educators worldwide. Research linking perceived gamified learning support to affective engagement and self-efficacy nevertheless remains scarce, and evidence on how such tools shape intrinsic and extrinsic learning motivation is limited, particularly in developing-country contexts such as Cambodia. This study examines the influence of perceived gamified learning support on students' intrinsic and extrinsic learning motivation, affective engagement, and self-efficacy. A quantitative correlational design was employed, with data collected from 73 students at a private university in Cambodia who had experienced gamified learning. Given the modest sample, the estimates were supported by bootstrapping with 5,000 resamples, and the hypothesised model was tested using structural equation modelling (SEM) with the diagonally weighted least squares estimator. Confirmatory factor analysis demonstrated good measurement model fit and strong construct validity. The SEM analysis revealed that perceived gamified learning support significantly influences students' intrinsic and extrinsic learning motivation, affective engagement, and self-efficacy, confirming all four study hypotheses. Grounded in self-determination theory and self-efficacy theory, the study demonstrates the role of gamification tools in supporting students' learning in the Cambodian higher education context, offering guidance for both researchers and practitioners. The findings suggest that educators should draw on gamification tools in their instructional design to foster students' learning motivation, affective engagement, and self-efficacy.

Keywords: gamification, intrinsic motivation, extrinsic motivation, affective engagement, self-efficacy, formative assessment, higher education

1. Introduction

The use of gamification tools in formative assessment and learning support is widely considered one of the most important emerging approaches in contemporary education [35, 59, 75]. It is well established that assessment plays a primary role in shaping students' learning experiences [24, 51], and formative assessment, in particular, has become a vital component in promoting active engagement, providing timely feedback, and supporting learning progression [31, 48, 67]. A notable feature of gamification tools is their ability to integrate assessment with game elements such as quizzes, points, badges, and leaderboards, and in recent years their application has grown substantially across diverse educational contexts [39, 44].

Gamified formative assessment is now attracting considerable attention for its role in shaping students' self-efficacy and learning motivation [8, 76]. Meccawy et al. [44] demonstrated that a game-based assessment approach positively affected students' self-efficacy, even where performance differences were mixed, and Benben and Bug-os [10] showed that gamified formative assessment in

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physics classes raised both academic achievement and motivation, intrinsic and extrinsic components alike. Self-efficacy, task value, and both forms of motivation have also been argued to predict student engagement in feedback and learning processes [21]. Reviews nevertheless highlight that, although gamification and motivation are well-established research interests, the specific pathways linking gamified assessment to self-efficacy remain underexplored [14]. Chavarría Oviedo and Avalos Charpentier [14] report that classroom gamification yields good results when games have clear objectives, that teachers must select games carefully and avoid overusing them, and that such tools foster motivation by creating an enjoyable, low-pressure environment conducive to active participation. They further characterise gamification as a useful means of assessing students' progress and providing feedback.

Four gaps remain. First, previous work has concentrated on general motivation and engagement outcomes, examining either intrinsic or extrinsic motivation in isolation or assuming their roles without testing them; where both have been examined, findings are inconsistent. Second, the role of gamified learning in shaping affective engagement and self-efficacy has largely been overlooked, so the pathways through which perceived gamified learning support fosters these outcomes are not well understood. Third, few studies have employed structural equation modelling (SEM) in gamified learning environments, which limits the evidence on how these outcomes are related within a single model. Fourth, little is known about any of this in the Cambodian higher education context.

This paper therefore investigates the impact of perceived gamified learning support on students' intrinsic and extrinsic learning motivation, affective engagement, and self-efficacy. Its contribution is to provide empirical evidence from an under-represented setting, to extend current knowledge of gamified support for learning, and to inform the design of assessments that better support student confidence and learning outcomes. The study was guided by the following research question: *How does perceived gamified learning support influence students' intrinsic and extrinsic learning motivation, affective engagement, and self-efficacy?*

2. Literature review

2.1. Gamification-based formative assessment and learning support

Gamification refers to the use of game elements (e.g., points, badges, leaderboards, and challenges) in non-game contexts, including education [16], while formative assessment provides continuous feedback to learners in order to improve the teaching and learning process [31, 69]. Christopoulos and Mystakidis [16] provide a comprehensive overview of gamification tools, covering application techniques, adaptation across educational levels, and the advantages and disadvantages of such tools. They emphasised that in higher education the integration of gamification may support student learning progress, foster a sense of achievement, and promote collaborative problem-solving.

Gamification tools have been widely used for formative assessment across global contexts [13, 47, 50, 59, 61], and studies indicate that they have the potential to increase students' motivation and active participation in learning [47, 50, 61]. For instance, Mohamad, Arif and Noor [47] examined the use of Quizizz (now Wayground) as a formative assessment tool among postgraduate students in Malaysia and found that its features foster positive learning motivation while providing the immediate feedback that reinforces students' learning. Similarly, Nguyen [50] investigated the use of Quizizz among English major students in Vietnam and reported improvements in learning performance, motivation, and self-regulation. The tool has also been found to enhance students' engagement and to foster a competitive learning environment [50, 59]. In a more recent study, Ramesh et al. [61] found that accounting students in Oman held positive perceptions of gamification tools as formative assessment, with gains in learning engagement most pronounced among female students.

The benefits of gamification in education extend beyond academic performance, engagement, and motivation. Polo-Peña, Frías-Jamilena and Fernández-Ruano [56] found that gamified formative assessment significantly influences self-efficacy, with female and older learners showing even greater responsiveness. An experimental study in Jordan found that Kahoot! reduced students' anxiety, improved their academic performance, and strengthened their self-efficacy in learning [2]. In another experimental study in Egypt, Othman et al. [53] combined Kahoot! and augmented reality with nursing students and found that this integration enhanced knowledge, motivation, and academic self-efficacy. These findings collectively highlight the broader role of gamification tools in supporting not only students' academic outcomes but also their motivation and self-regulatory development. Despite the growing worldwide use of gamification tools for formative assessment, empirical research on gamification-based formative assessment in Cambodian higher education remains limited.

2.2. Intrinsic and extrinsic learning motivation and gamification tools

Intrinsic and extrinsic motivation describe, respectively, the internal and external drives that lead people to learn. Intrinsically motivated learners are curious, show interest, and take enjoyment in their learning [65]; learners driven by external factors such as grades, rewards, or competition are extrinsically motivated [3, 17]. Ryan and Deci [66] found that learning motivation not only influences students' engagement but also fosters confidence and well-being, and that teachers and the institutional context shape this motivation, underlining how much both matter in supporting it.

In the context of gamified formative assessment, Razali et al. [62] found that engineering students in Malaysia reported moderate motivation in a gamified classroom, with game elements such as points, difficulty, and avatars emerging as the key predictors: points predicted both intrinsic and extrinsic learning motivation, while avatars and difficulty predicted extrinsic motivation alone. A review of the wider evidence reaches similar conclusions [58]. A systematic review by Jaramillo-Mediavilla et al. [32] broadened this picture, showing how gamified elements foster motivation and how such tools develop competencies including cognitive development, social learning, teamwork, and problem-solving. Features such as progress dashboards help students monitor their own learning, while immediate feedback and interactivity make it more enjoyable [11, 32]. Perceived collaboration, competition, favourable feedback, self-expression, and a sense of control have each been found to predict intrinsic motivation [41], and Xu et al. [74] likewise found that points, leaderboards, badges, and social interaction enhance it.

Prior studies indicate that both intrinsic and extrinsic learning motivation can be enhanced by integrating gamification into education, although balancing the two remains a practical challenge. In a quasi-experimental study, students in a gamified learning environment reported higher learning motivation and self-efficacy and more favourable achievement emotions, suggesting that gamified tools can improve not only academic outcomes but also academic and achievement motivation [38]. A meta-analysis and systematic review found that gamification fosters intrinsic learning motivation and perceptions of autonomy and relatedness, but has a relatively small effect on perceived competence [37]. Feng et al. [19] similarly found that careful learning design and the integration of appropriate strategies can strengthen students' autonomy, competence, and relatedness through gamification.

2.3. Self-efficacy for learning and performance in a gamified learning environment

Self-efficacy refers to a person's confidence and belief in their ability to perform a specific task [43]. Self-efficacy for learning and performance (SELP) is the corresponding confidence in one's ability to perform well academically. Bandura [5] emphasised that self-efficacy judgements influence the choice of activities and environmental settings, determine effort and persistence in the face of obstacles, and shape thought patterns and emotional reactions.

Trautner and Schwinger [72] found that students with higher self-efficacy for motivation regulation reported more frequent use of motivation regulation strategies, which indirectly increased their effort, although no significant interaction with strategy use was observed; self-efficacy for motivation regulation was more strongly linked to positive affect than to academic grades, indicating a greater influence on the motivational and emotional aspects of learning than on achievement itself. Alemayehu and Chen [1] found that motivation positively influenced learning self-efficacy, self-monitoring, and learning engagement, with self-efficacy and self-monitoring partially mediating this relationship. Teacher support has likewise been shown to raise students' creative self-efficacy, with autonomous motivation and positive emotions such as enjoyment and relaxation acting as key mediators [40], while teaching beliefs and attitudes predict motivation to teach, with self-efficacy mediating that link [7].

Turning to gamification specifically, Hsiao et al. [28] found that high school students who learned about the Internet of Things through gamification combined with the 6E model achieved significantly higher computer programming self-efficacy, subject knowledge, and practical skills than those taught with the 6E model alone or through the software development method. Students in the gamified group also showed more positive interaction, collaboration, and initiative in seeking help, which led to stronger outcomes in STEM activities. Khaledi et al. [34] found that both gamification and role-play significantly improved nursing students' cardiopulmonary resuscitation self-efficacy relative to conventional lecture-based instruction, with these two active learning strategies proving more effective than the lecture format in building students' confidence, knowledge, and practical skills. How SELP develops within technology-enhanced environments, and under gamified learning support in particular, has nonetheless received little attention.

3. Theoretical framework

Gamification integrates game elements such as points, badges, and challenges into learning in order to enhance motivation, engagement, and performance [16, 33, 59]. Perceived gamified learning support (GLS) refers to students' perception of how gamified elements facilitate their learning through feedback, goals, and incentives. In self-determination theory (SDT), motivation arises from the satisfaction of three basic psychological needs: autonomy, competence, and relatedness [65]. Gamified learning environments can enhance intrinsic learning motivation (ILM) by making learning enjoyable and self-directed, and extrinsic learning motivation (ELM) through structured rewards and recognition [26, 41, 70]. They can also increase affective engagement (AE), as interactive and rewarding activities capture students' emotional involvement [4, 30, 63], while gamified feedback and incremental challenges strengthen SELP by helping students feel more confident in accomplishing tasks [15, 44, 68].

3.1. Conceptual framework

The conceptual framework of this study, shown in figure 1, sets out the hypothesised relationships between perceived GLS and four learning outcomes: ILM, ELM, AE, and SELP. Drawing together SDT [65] and self-efficacy theory [6], it treats perceived GLS as a single exogenous construct with a direct effect on each outcome, and so provides a structure for testing those four effects simultaneously. Because research suggests that gamified learning environments enhance motivation, engagement, and self-efficacy, students who perceive higher levels of gamified learning support are expected to report higher levels of all four outcomes.

3.2. Specific hypotheses

H1: Perceived GLS positively influences ILM. Students who perceive greater support from gamified learning are more likely to experience higher intrinsic motivation in learning activities.

H2: Perceived GLS positively influences ELM. Students who perceive greater support from gamified learning are more likely to experience higher extrinsic motivation, such as reward- or recognition-driven motivation.

H3: Perceived GLS positively influences AE. Students who perceive greater support from gamified learning are more likely to demonstrate higher emotional involvement and interest in learning activities.

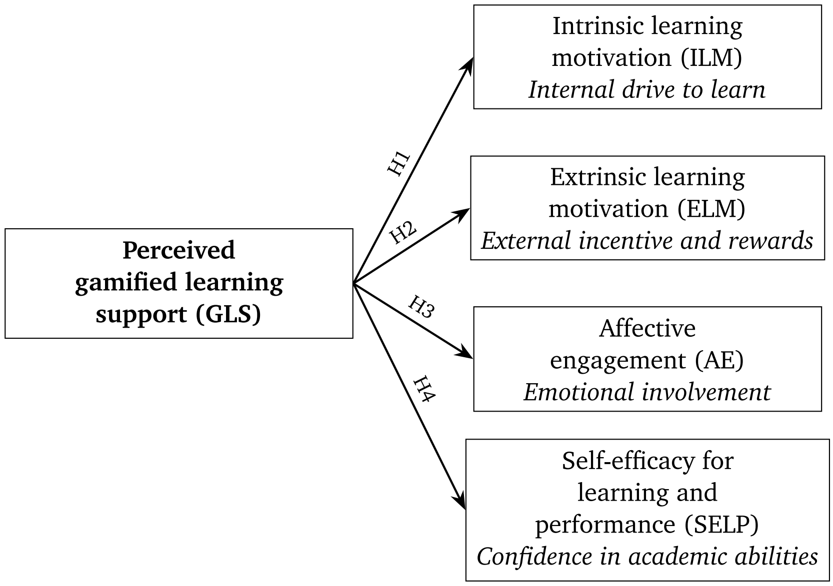

Figure 1: Conceptual framework of the study.

H4: Perceived GLS positively influences SELP. Students who perceive greater support from gamified learning are more likely to have higher confidence in their ability to succeed in learning tasks.

4. Method

4.1. Research design

This study employed a quantitative correlational design to examine the relationships among perceived GLS, ILM, ELM, AE, and SELP. While correlational designs do not allow strong causal inferences, they are appropriate for exploring predictive associations and generating evidence about potential mechanisms that may be tested in future experimental studies [20]. SEM was chosen to examine these relationships because it is well suited to testing theoretically driven models [12]: confirmatory factor analysis (CFA) was conducted first to validate the measurement model, followed by SEM to test the hypothesised structural model.

4.2. Population and sample

Sampling proceeded in two stages. Purposive sampling was first used to select a private university in Cambodia and, within it, three classes that employed gamification tools in their teaching and learning; these classes contained 96 students in total. Simple random sampling was then used to draw 73 students from this population, so that every student in the three classes had an equal chance of taking part, giving a response rate of 76%. Participation was voluntary, and informed consent was obtained before data collection. Because the study relied on self-reported data, participants were assured that their responses would remain confidential and be used solely for research purposes, in order to reduce the risk of common method bias [55].

Table 1 presents the demographic profile of the participants. Of the 73 students, 50 (68.49%) were female and 23 (31.51%) male, and the great majority, 66 (90.41%), were aged 18–24 years. By level of study, 58 (79.45%) were second-year students and 15 (20.55%) fourth-year students. Their majors were English (15, 20.55%), Accounting (25, 34.25%), and Agriculture (33, 45.21%).

Table 1
Demographics of participating students.

Variable	Sub-group	*N*	%
Gender	Female	50	68.49
	Male	23	31.51
Age	Under 18 years old	3	4.11
	18–24 years old	66	90.41
	25–34 years old	4	5.48
Level of education	Year 2	58	79.45
	Year 4	15	20.55
Majoring	English	15	20.55
	Accounting	25	34.25
	Agriculture	33	45.21

Note. $N = 73$. Percentages may not total 100 owing to rounding.

4.3. Data collection

Data were collected during the academic year 2024–2025 at a private university in Cambodia, following institutional approval. Participants were students who had experienced gamified learning through tools such as Kahoot! and Quizizz in their courses. The questionnaire was administered in person using Google Forms and took approximately 12 minutes to complete.

4.4. Instruments

Three of the constructs were measured using self-report subscales adapted from Pintrich et al. [54]: intrinsic learning motivation, extrinsic learning motivation, and self-efficacy for learning and performance. The ILM scale consists of 6 items measuring students' intrinsic interest and enjoyment in learning, e.g., "*I prefer course content from which I can learn new things*". The ELM scale consists of 6 items evaluating motivation driven by external rewards and recognition, e.g., "*The most satisfying thing for me is to get a good grade*". The SELP scale consists of 7 items assessing students' confidence in their ability to succeed in academic tasks, e.g., "*I'm certain I can understand difficult course material in this semester*".

These instruments were adapted through a translation and back-translation procedure [9]. The original English instruments were first translated into Khmer by three bilingual Cambodian researchers. The Khmer versions were then independently back-translated into English and compared with the original scales to verify semantic equivalence. The finalised Khmer instruments were pilot-tested with 10 undergraduate students to evaluate the clarity and suitability of the items.

Two further subscales, perceived GLS and AE, were developed by the researcher for the current study on the basis of the literature review. The perceived GLS scale consists of 11 items measuring students' perception of how gamified elements support their engagement, motivation, and performance, e.g., "*When using Kahoot!/Quizizz, the immediate feedback helps me understand what I know and don't know*". It represents the role of challenge, competition, feedback, and self-monitoring in supporting students' learning and improvement. The AE scale consists of 6 items measuring students' emotional involvement, enthusiasm, and interest in learning activities, e.g., "*When using Kahoot!/Quizizz, I feel motivated to participate actively in class activities*".

The validity of these two scales was assessed through consultation with three researchers from a major public university, who examined the relevance, clarity, and language of the items in both Khmer and English [18]. Their feedback, which concerned mainly ambiguous wording and item phrasing, was used to revise the questionnaire before pilot testing. Content validity was thus derived from the literature review, while face validity was confirmed through expert evaluation [71]. All items were measured on a 5-point Likert scale (from 1 = strongly disagree to 5 = strongly agree).

Cronbach's α for GLS, ILM, ELM, AE, and SELP was 0.95, 0.89, 0.91, 0.93, and 0.93, respectively (see table 6).

4.5. Research context

In this study, two gamification tools, Kahoot! and Quizizz, were used as formative assessment activities in the classroom. These tools were integrated into the course on a weekly basis, both during and after lessons, to reinforce content knowledge and monitor student understanding. Specifically, game elements such as real-time quizzes, point systems, leaderboards, and immediate feedback were employed to engage students in the learning process. During lessons, these tools were used to check comprehension and stimulate active participation, while post-lesson activities served to consolidate learning and provide students with timely feedback on their performance. This integration of gamification mechanics into regular formative assessment practice represents the pedagogical technology under investigation in the current study.

4.6. Data analysis

Data analyses were conducted using JASP version 0.19.3. Descriptive statistics, including means and standard deviations, were computed for perceived gamified learning support, affective engagement, learning motivation, and self-efficacy, and skewness and kurtosis were assessed to evaluate the normality of the data. CFA was then conducted to evaluate the measurement model, using the comparative fit index (CFI), the Tucker-Lewis index (TLI), the standardised root mean square residual (SRMR), and the root mean square error of approximation (RMSEA) with its 90% CI. Convergent validity and internal consistency were assessed through factor loadings, average variance extracted (AVE), composite reliability (CR), and the reliability coefficients ω and α.

SEM was used to assess the relationships among the study constructs, since it can model complex relationships involving latent variables, handle measurement error, and analyse multiple dependent variables simultaneously [52]. Although SEM is typically recommended for larger samples, reliable results can be obtained with smaller ones ($N < 100$) when models are relatively simple, indicators load strongly, and bootstrapping is applied [49, 73]. Wolf et al. [73] report that, for a one-factor model with four indicators, factor loadings of 0.80, 0.65, and 0.50 call for minimum sample sizes of 60, 90, and 190 respectively, while the corresponding minima for a one-factor model with six indicators fall to 40, 60, and 90. Stronger loadings and more indicators per factor therefore permit substantially smaller samples. Accordingly, the SEM analyses in this study were conducted with 5,000 bootstrap resamples, which yield more accurate confidence intervals and reduce bias in small samples [25, 57]. The models were estimated using diagonally weighted least squares (DWLS), an estimator suited to the ordinal nature of the survey indicators and robust to non-normality in ordinal data [36, 46].

4.7. Ethical considerations

Participants received detailed information about the purpose of the study before taking part, and the questionnaire cover page stated that submitting a response constituted consent to the use of the data for research and publication. Participation was voluntary and could be withdrawn at any point before submission, without reason. No personally identifying information was collected, and all responses were coded and analysed in aggregate form.

5. Results

5.1. Descriptive statistics and bivariate correlations

Table 2 presents the descriptive statistics and table 3 the bivariate correlations for the study variables. Skewness ranged from −1.00 to −0.56 and kurtosis from −0.69 to 0.25, suggesting that the data are approximately normally distributed [12, 22]. Perceived GLS was strongly and positively associated with ILM, ELM, AE, and SELP ($r = 0.66$ to 0.80), and both ILM and ELM were also strongly correlated with AE and SELP (see table 3).

Table 2
Descriptive statistics.

Variable	GLS	ILM	ELM	AE	SELP
Mean	4.54	4.53	4.38	4.53	4.47
Std. deviation	0.52	0.49	0.62	0.56	0.52
Skewness	−0.91	−0.73	−0.82	−1.00	−0.56
Std. error of skewness	0.28	0.28	0.28	0.28	0.28
Kurtosis	−0.06	−0.26	0.25	0.06	−0.69
Std. error of kurtosis	0.56	0.56	0.56	0.56	0.56

Table 3
Bivariate correlations.

Variable	GLS	ILM	ELM	AE	SELP
1. GLS	–				
2. ILM	0.80***	–			
3. ELM	0.70***	0.66***	–		
4. AE	0.80***	0.66***	0.65***	–	
5. SELP	0.66***	0.71***	0.75***	0.56***	–

* $p < .05$, ** $p < .01$, *** $p < .001$.

5.2. Assessment of common method variance

The Kaiser-Meyer-Olkin measure verified the sampling adequacy of the data (KMO = 0.813, 'meritorious'), and Bartlett's test of sphericity was significant ($\chi^2(630) = 3042.078$, $p < .001$), indicating that the correlation matrix was suitable for factor analysis.

Harman's single-factor test showed that the first unrotated factor accounted for 53.47% of the total variance, marginally above the conventional 50% criterion. After rotation, however, variance was distributed fairly evenly across the five extracted factors, the largest of which accounted for 19.02% (see table 4), so no single method factor dominates the solution. Taken together with the procedural safeguards described in subsection 4.2, this suggests that common method bias is unlikely to account for the observed relationships, although it cannot be ruled out entirely.

Table 4
Total variance explained for Harman's single-factor test.

Component	Initial eigenvalue	% of variance (unrotated)	% of variance (rotated)
1	19.25	53.47	19.02
2	3.18	8.83	18.03
3	1.76	4.88	15.20
4	1.36	3.77	11.18
5	1.13	3.14	10.66

5.3. Confirmatory factor analysis

A CFA was conducted using the DWLS estimator to examine the factorial validity of the measurement model. Although the model χ^2 was significant, $\chi^2(584) = 734.11$, $p < .001$, its ratio to the degrees of freedom was low (1.26), and the incremental indices computed against the baseline model, $\chi^2(630) = 9435.13$, indicated close fit: CFI = 0.98, TLI = 0.98, RMSEA = 0.06 with 90% CI [0.045, 0.073], and SRMR = 0.08 (see table 5) [22, 29]. All indices met conventional thresholds (CFI, TLI ≥ 0.90; RMSEA ≤ 0.08; SRMR ≤ 0.08–0.09), indicating that the measurement model adequately represents the observed data and providing evidence of construct validity for all five latent variables. These findings justify the use of the constructs in the subsequent structural equation modelling analyses.

Table 5
Global model fit indices.

Fit index	Value	Threshold	Interpretation
CFI	0.98	≥ 0.90	Excellent fit
TLI	0.98	≥ 0.90	Excellent fit
RMSEA	0.06	≤ 0.08	Acceptable fit
RMSEA 90% CI	[0.045, 0.073]	–	–
SRMR	0.08	≤ 0.08	Acceptable fit

The AVE values (0.60 to 0.69) and CR values (0.90 to 0.95) support convergent validity [22, 29], and the reliability coefficients were high ($\omega = 0.90$–0.95; $\alpha = 0.89$–0.95), indicating strong internal consistency (see table 6) [22]. All factor loadings were statistically significant and ranged from 0.67 to 0.91 ($p < .001$), confirming that the indicators adequately measured their latent constructs [22]. Discriminant validity was assessed using the heterotrait–monotrait (HTMT) ratio [23, 27]. All HTMT values were at or below the conservative threshold of 0.85, providing evidence that the constructs were empirically distinct [23, 27, 64] (see table 7). The highest values, both 0.85, involved perceived GLS with ILM and with AE. These constructs are conceptually separable: perceived GLS captures students' perceptions of gamified instructional elements, ILM their internal motivation to engage with learning, and AE their emotional involvement and enjoyment during learning activities. Despite the strong associations between them, they therefore represent distinct aspects of the learning experience, consistent with theory and prior research. Given the small sample ($N = 73$) and the use of 5,000 bootstrap resamples, these statistics provide sufficient grounds for interpreting the SEM results [23, 45, 57].

Table 6
Factor loadings and reliability.

Factor	Items	Standardised loadings	AVE	CR	ω	α
GLS	GLS1–GLS11	0.68–0.88	0.65	0.95	0.95	0.95
ILM	ILM1–ILM6	0.69–0.83	0.60	0.90	0.90	0.89
ELM	ELM1–ELM6	0.73–0.91	0.64	0.91	0.91	0.91
AE	AE1–AE6	0.67–0.90	0.69	0.93	0.93	0.93
SELP	SELP1–SELP7	0.69–0.88	0.67	0.93	0.93	0.93

Note. Loadings are standardised factor loadings. ω = McDonald's omega; α = Cronbach's alpha.

Table 7
Heterotrait-monotrait ratio.

	GLS	ILM	ELM	AE	SELP
1. GLS	1				
2. ILM	0.85	1			
3. ELM	0.75	0.71	1		
4. AE	0.85	0.71	0.72	1	
5. SELP	0.66	0.75	0.80	0.59	1

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Table 8
Structural model estimated with 5,000 bootstrap resamples.

Path	β	SE	z-value	p	95% bootstrap CI
GLS → ILM	0.88	0.04	23.73	$< .001$	[0.80, 0.95]
GLS → ELM	0.76	0.06	13.07	$< .001$	[0.64, 0.87]
GLS → AE	0.85	0.04	21.31	$< .001$	[0.77, 0.93]
GLS → SELP	0.71	0.06	11.16	$< .001$	[0.59, 0.84]

Note. β = standardised regression coefficient; SE = standard error; z-value = t-value from bootstrapping; p = significance level; 95% bootstrap CI = 95% confidence interval calculated from 5,000 bootstrap resamples.

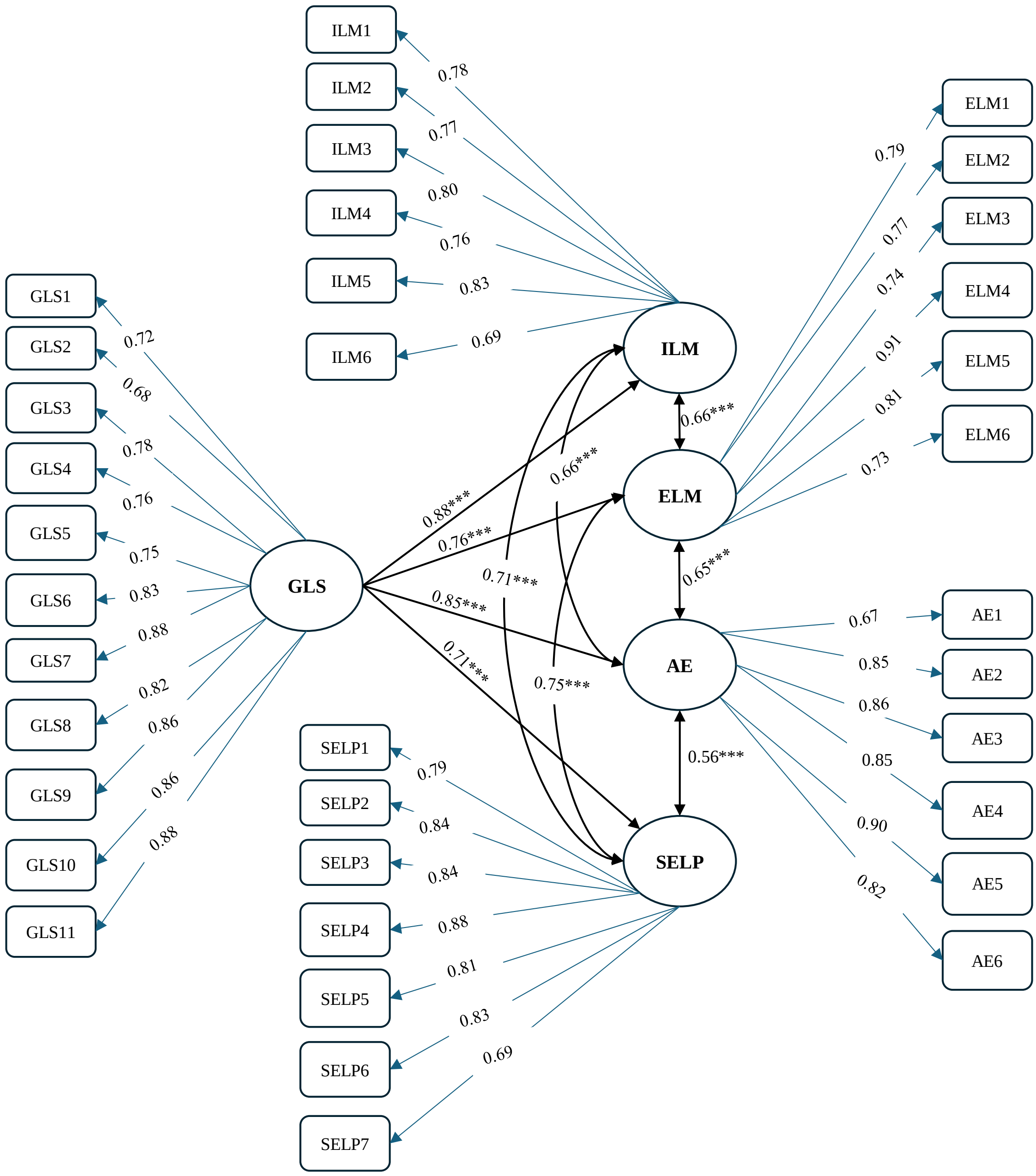

Figure 2: Structural equation model estimated using the bootstrapping method (5,000 resamples). *Note*. Standardised path coefficients are shown. Single-headed arrows represent directional (structural) effects between latent variables, whereas double-headed arrows represent correlations between variables. Statistical significance is indicated as follows: $*p < .05$; $**p < .01$; $***p < .001$.

5.4. Structural model

The sample ($N = 73$) is relatively small in relation to the complexity of the model (five latent variables with 36 indicators). Several features of the analysis nonetheless support the stability of the estimates. The measurement model showed strong standardised factor loadings, high composite reliability, and adequate convergent validity, all indicating low measurement error. The structural component is also relatively simple, with a single exogenous construct predicting four endogenous variables, which reduces estimation complexity compared with more elaborate specifications (figure 2). Because that structural component is saturated – one exogenous latent variable predicting four endogenous latent variables whose residuals were freely correlated – it is statistically equivalent to the measurement model, and its fit is therefore that reported in table 5. Finally, 5,000 bootstrap resamples were used to address potential small-sample bias and non-normality, yielding robust standard errors and confidence intervals, as is recommended for SEM with limited sample sizes.

As table 8 shows, the structural model revealed strong and statistically significant relationships between perceived GLS and every outcome variable. GLS had a very strong positive effect on intrinsic learning motivation ($\beta = 0.88$, $p < .001$) and affective engagement ($\beta = 0.85$, $p < .001$), and a strong positive effect on extrinsic learning motivation ($\beta = 0.76$, $p < .001$) and self-efficacy for learning and performance ($\beta = 0.71$, $p < .001$). All four hypothesised paths were thus supported, indicating that perceived gamified learning support plays a central role in students' motivational, affective, and self-belief outcomes.

6. Discussion

This study examined the effects of perceived GLS on students' ILM and ELM, AE, and SELP in a Cambodian higher education context. The SEM results indicated that GLS positively and significantly predicted all four outcome variables, confirming the central role of gamified learning support in shaping motivational, affective, and self-belief outcomes.

6.1. Perceived gamified learning support and intrinsic learning motivation

Perceived GLS was the strongest predictor of intrinsic learning motivation ($\beta = 0.88$, $p < .001$), accounting for roughly three-quarters of its variance. SDT anticipates this pattern: gamified formative assessment supplies immediate feedback, calibrated challenge, and visible progress, and it is the satisfaction of the needs for competence and autonomy, rather than the game elements in themselves, from which motivation follows [65]. The direction of the result is consistent with the body of work reviewed above, in which particular mechanics, and the qualities students perceive in them, predict intrinsic motivation [41, 58, 59, 62, 74]. What the present model adds is magnitude. That a global perception of support, rather than any single mechanic, carries so much of the effect suggests that how students read the gamified environment matters more than the inventory of features it contains – a reading consistent with the emphasis in prior work on progress dashboards and interactivity as means of making learning legible to the learner [11, 32].

6.2. Perceived gamified learning support and extrinsic learning motivation

Perceived GLS also positively influenced extrinsic learning motivation ($\beta = 0.76$, $p < .001$). Grades, rewards, and competition are the classic sources of externally regulated behaviour [3, 17], and leaderboards, scores, and public recognition supply them directly, which supports the view that such structures drive performance-oriented behaviours [42, 70]. The more informative result is that this path and the intrinsic path were both strong. Gamified formative assessment did not, in this sample, purchase extrinsic motivation at the cost of intrinsic motivation; the two rose together. A correlational design cannot establish whether that balance holds under sustained exposure, and the teaching and institutional context in which the tools are embedded plausibly conditions it [66].

6.3. Perceived gamified learning support and affective engagement

The effect of perceived GLS on affective engagement was likewise strong ($\beta = 0.85$, $p < .001$), indicating that gamified learning environments promote emotional involvement, enthusiasm, and interest in learning tasks. This is consistent with research showing that interactive, game-like activities heighten emotional engagement and foster active participation [4, 30]. Affective engagement and intrinsic motivation nonetheless remained empirically distinct (HTMT = 0.71), which supports treating enjoyment during an activity and the disposition to learn as related but separable constructs rather than as two labels for the same response.

6.4. Perceived gamified learning support and self-efficacy for learning and performance

Perceived GLS positively influenced SELP ($\beta = 0.71$, $p < .001$). Self-efficacy theory attributes efficacy beliefs above all to mastery experience, supported by feedback and goal setting [5], and repeated low-stakes quizzing with immediate feedback offers exactly that: frequent, interpretable evidence of what a student can already do. The finding aligns with experimental studies showing that gamified learning enhances academic self-efficacy and reduces performance anxiety [2, 53, 56], and with the nursing education evidence discussed earlier [34]. The competencies such tools develop – cognitive, collaborative, and problem-solving [32, 60] – may themselves feed the self-beliefs that underpin subsequent performance [6].

This path was, however, the weakest of the four. The ordering is theoretically coherent: efficacy beliefs are anchored in an accumulated history of performance and are correspondingly less responsive to a single instructional format than either motivation or in-the-moment affect. Gamified formative assessment appears to shift how students feel about learning more readily than what they believe themselves capable of achieving.

6.5. Theoretical and practical implications

These findings extend the literature by showing that perceived gamified learning support acts on several dimensions of learning at once, influencing motivation, affective engagement, and self-efficacy simultaneously rather than through any one channel. Integrating game elements into formative assessment therefore offers a means of supporting not only cognitive outcomes but also the emotional and self-belief factors on which learning depends. The results are particularly relevant to the Cambodian higher education context, where research on gamified assessment remains limited.

6.6. Limitations and directions for future research

Despite its contribution, this study has several limitations. First, the correlational design limits causal inference: strong associations were observed, but experimental or longitudinal designs are needed to establish the directionality of the effects. Second, the sample ($N = 73$) is relatively small for a model of this complexity, and the number of indicators adds to that complexity, which may restrict the generalizability of the findings; the use of bootstrapping, the high factor loadings, and the model fit indices provide some assurance about the stability of the estimates [49, 73], but replication with larger samples remains essential. Third, all constructs were measured by self-report at a single point in time. The rotated factor solution indicates that no single method factor dominates, yet common method variance cannot be entirely excluded, and future work would benefit from behavioural or performance measures alongside self-report [55]. Fourth, although the researcher-developed scales (GLS and AE) were validated through translation, back-translation, expert review, pilot testing, and CFA, these instruments should be evaluated further in other contexts to strengthen construct validity.

Three directions follow. Future research should employ longitudinal and experimental designs with larger and more diverse samples, both to strengthen causal inference and to improve generalizability. It should examine mediating and moderating mechanisms – perceived challenge, achievement emotions, or prior digital literacy, and particularly the role of motivational constructs in mediating the relationship between GLS and self-efficacy. Finally, isolating the relative contributions of specific gamification elements such as badges, leaderboards, and immediate feedback would give educators practical guidance for optimising gamified assessment strategies.

7. Conclusion and implications

This study demonstrates that perceived gamified learning support positively influences intrinsic and extrinsic learning motivation, affective engagement, and self-efficacy for learning and performance. It contributes to theory by showing how SDT and self-efficacy theory can be brought together to account for the several dimensions of student learning that gamified environments affect, and it shows that these effects differ in strength, with motivation and affect more responsive than self-efficacy. Practically, the findings indicate that gamified formative assessment can strengthen both the motivational and the emotional aspects of learning, and that educators should integrate elements such as immediate feedback, challenge, and recognition into formative assessment with those ends in view. The results also provide empirical evidence specific to the Cambodian higher education context, offering a basis for curriculum design, instructional planning, and the development of gamified assessment tools.

Conflicts of interest

The author declares that there are no competing interests.

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Data availability statement

Data from this study are available from the corresponding author upon reasonable request.

Ethics approval

The study was conducted following institutional approval. All participants received detailed information about the purpose of the study before taking part. Participation was voluntary, and participants were free to withdraw at any time before submitting the questionnaire, without giving a reason. The questionnaire cover page stated clearly that, by submitting their responses, participants consented to the use of their data for research and publication purposes. No personally identifying information was collected, and all responses were coded and analysed in aggregate form to ensure confidentiality and anonymity.

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A. Research instrument

Intrinsic learning motivation

In this class, ...

1. I prefer course content from which I can learn new things.
2. I prefer course content that satisfies my curiosity even if it is difficult to learn.
3. The most satisfying thing for me is trying to understand course content as much as I can.
4. I choose assignments from which I can learn new things even if they don't guarantee a good grade.

5. Trying to learn new things as much as I can is the most satisfying thing for me.
6. I like to learn course content or do assignments that can improve my abilities or skills.

Extrinsic learning motivation

In this class, . . .

1. The most satisfying thing for me is to get a good grade.
2. If I can, I want to get better grades than most of my classmates.
3. I need to perform well because I want to show off my ability.
4. Getting a good grade is my main concern.
5. It is important for me to improve my overall grade point average.
6. I study hard because I want my family or friends to feel proud of me.

Self-efficacy for learning and performance

1. I believe I will receive an excellent grade in this semester.
2. I'm certain I can understand difficult course material in this semester.
3. I'm confident I can understand the key concepts taught in this semester.
4. I'm confident I can understand the most complex material taught in this semester.
5. I'm confident I can do well on my homework or assignments in this semester.
6. I expect to do well in this semester.
7. I'm certain I can master the skills being taught in this semester.

Affective engagement

Items reflecting students' emotional responses, enjoyment, and active involvement when using Kahoot! or Quizizz:

1. When using Kahoot!/Quizizz, I have fun while learning.
2. When using Kahoot!/Quizizz, I feel more engaged compared to traditional lessons.
3. When using Kahoot!/Quizizz, I feel motivated to participate actively in class activities.
4. When using Kahoot!/Quizizz, I feel excited to answer each question.
5. I enjoy the process of learning through Kahoot!/Quizizz more than traditional lessons.
6. Using Kahoot!/Quizizz makes learning feel less like a task and more like a game.

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Gamified learning support

Items representing the role of challenge, competition, feedback, and self-monitoring in supporting students' learning and improvement:

1. When using Kahoot!/Quizizz, the challenge pushes me to think faster.
2. When using Kahoot!/Quizizz, I feel encouraged to improve my score compared to previous attempts.
3. I like the feeling of competing with my classmates in Kahoot!/Quizizz.
4. The challenge of Kahoot!/Quizizz questions encourages me to think carefully before answering.
5. I feel a sense of achievement when I do better than in my previous attempts.
6. When using Kahoot!/Quizizz, the immediate feedback helps me understand what I know and don't know.
7. When using Kahoot!/Quizizz, the feedback helps me correct my mistakes.
8. When using Kahoot!/Quizizz, I feel the activity improves my understanding of the lesson.
9. The feedback from Kahoot!/Quizizz helps me identify areas I need to study more.
10. I can use the results from Kahoot!/Quizizz to improve my learning in future lessons.
11. Kahoot!/Quizizz activities provide me with useful insights into my strengths and weaknesses.