



Evaluating Behavior-Driven Metrics in Gamified Hybrid Environments: A Structural Analysis Approach

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Abstract. Despite the widespread adoption of gamification in higher education, a significant research gap remains regarding the structural pathways through which specific game elements influence psychological drivers and academic success in hybrid settings. This study addresses this by evaluating the impact of badges, points, progress bars, and leaderboards on student motivation and outcomes using a quantitative approach with a sample of 437 university students in Indonesia. Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM), revealing that the model possesses strong internal consistency and convergent validity, with factor loadings between 0.760–0.956 and Average Variance Extracted (AVE) values ranging from 0.687 to 0.872. The structural analysis confirms that badges act as a primary driver for perceived playfulness and the effectiveness of other elements, while leaderboards and progress bars significantly enhance learning satisfaction; however, points showed no significant impact on playfulness. These findings, evidenced by significant path coefficients (β) and robust R^2 values, provide an analytical framework for educators to strategically design gamified ecosystems that prioritize high-impact behavioral metrics over simple reward systems, thereby optimizing engagement in blended learning environments.

Keywords: Gamification, blended learning, perceived playfulness, learner analytics, structural modelling, partial least squares

(Received 2025-08-04, Revised 2026-03-16, Accepted 2026-05-05, Available Online by 2026-06-09)

1. Introduction

The incorporation of gamification into Learning Management Systems (LMS) has progressed from mere aesthetic enhancements to complex, behavior-driven architectures. In hybrid or blended learning

ecosystems, these digital platforms rely on synchronized feedback loops—including badges, points, and leaderboards—to sustain engagement among students across both asynchronous and synchronous modalities. Recent systematic studies indicate that consistent gamification implementation positively impacts learning motivation and emotional engagement across diverse hybrid environments [1,2]. However, the engineering of these systems frequently adopts a "one-size-fits-all" approach, focusing on the deployment of mechanics without a deep understanding of the structural interdependencies between specific metrics and the user's cognitive-behavioral response.

Despite the proliferation of gamified platforms, a critical technical ambiguity remains regarding which specific behavior-driven metrics actually catalyze academic performance. Many systems suffer from "reward fatigue," where elements like points or badges are implemented in isolation, failing to create a cohesive structural impact on the learner's motivation. In hybrid environments, where the digital interface serves as the primary bridge for knowledge transfer, the lack of a validated structural model leads to suboptimal system design and diminished instructional efficacy [3]. Recent longitudinal evidence suggests that students participating in gamified learning approaches show substantially elevated academic achievement compared to conventional methods [4], yet the precise internal mechanics of these systems remain under-analyzed through a structural lens.

While existing literature extensively covers the general advantages of gamification, there is a significant research gap in quantitative structural analysis that maps the hierarchical relationship between individual gamification components. For instance, although visualization elements are known to improve user satisfaction [5], there is insufficient empirical evidence—particularly within Indonesia's higher education digital infrastructure—to validate how these metrics interact within a unified structural equation [6]. Furthermore, it is crucial to ensure that gamification designs are sustainable and do not lose their efficacy over time [7].

To fill in these gaps, this investigation uses Partial Least Squares Structural Equation Modeling (PLS-SEM) to examine a behavior-driven framework. We aim to dissect the granular impact of four key metrics—badges, points, progress bars, and leaderboards—to determine their individual and collective contribution to perceived playfulness and learning outcomes. By doing so, this research provides a technical blueprint for developing more effective, data-driven gamified learning ecosystems in hybrid educational contexts.

The utilization of gaming elements, including badges, points, progress indicators, and leaderboards, helps boost engagement among students and positive behaviors in the classroom is known as "gamification" in education [8]. Recent studies indicate that the implementation of gamification can improve focus, engagement, and learning outcomes, particularly when these elements are contextually designed and tailored to the characteristics of learners [9,10]. However, the effectiveness of each gamification element varies, and there is still a paucity of research that structurally elucidates the psychological pathways through which these elements influence learning outcomes.

Prior studies have concentrated on the immediate impacts of gamification on motivation or learning performance; however, there has been limited integration of intermediary variables such as perceived playfulness, information overload, and learning satisfaction within a comprehensive model [11,12]. A thorough understanding of the relationships among these psychological variables is crucial for developing effective digital learning systems, particularly within the dynamic and complex ecosystem of blended learning.

Perceived playfulness, or the perception of enjoyment in learning, plays a significant role as a mediator that bridges gamification and learning outcomes. Studies indicate that enjoyable learning experiences not only enhance intrinsic motivation but also strengthen perceptions of control and satisfaction with the learning process [13]. In the digital context, elements of playfulness have emerged as key predictors of the success of technology-based learning.

This investigation aims to develop a comprehensive understanding of how gamification elements function within blended learning environments and how they influence students' learning experiences and outcomes. Specifically, the study seeks to formulate and empirically validate a structural model that explains the roles of key gamification components—such as badges, points, progress bars, and

leaderboards—within educational settings [13]. Through this model, the research examines how these gamification elements contribute to enhancing students’ enjoyment in learning, strengthening their motivation, increasing their level of satisfaction with the learning process, and ultimately improving their learning outcomes in blended learning environments [13]. Furthermore, by analyzing both the direct and indirect relationships among these variables, this study aims to provide empirical evidence and practical insights that can inform the design and development of more engaging, motivating, and effective digital learning systems[13].

2. Methods

This investigation utilized a quantitative methodology with a cross-sectional survey design to examine the structural relationships between gamification elements, learning motivation, perceived playfulness, and learning outcomes within the context of blended learning. Data were collected from 437 higher education students who have experience in using blended learning platforms that integrate gamification elements, such as Google Classroom, Moodle, and SPADA, in conjunction with face-to-face sessions. The research instrument utilized was a structured questionnaire that was devised using constructs that have been validated in previous studies. It employed a 5-point Likert scale to examine each variable. The acquired data was evaluated utilizing Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS 4.0 software to test the reliability, construct validity, and relationships among latent variables. This methodology was selected to provide robust and in-depth results in testing the proposed structural model and to offer empirical insights into the dynamics of learning motivation influenced by the implementation of gamification in blended learning.

2.1. Instrument Design

The research instrument was designed as a structured questionnaire comprising several sections to measure the key constructs in the research model, namely perceived playfulness, gamification elements (points, badges, leaderboard, progress bar), perceived satisfaction, motivation to learn, and learning outcomes. Each construct was measured using several indicators adapted and modified from previously validated studies, with adjustments made for the context of blended learning. The questionnaire was created using Google Forms, targeting respondents from various public universities on the island of Java, Indonesia. The questionnaire included instructions for completion, as well as demographic information such as gender, year of study, province, blended learning platform, and duration of gamification usage, as presented in Table 1. This study employed a quantitative method, with data collection conducted through the use of the questionnaire. The sample comprised 223 male respondents (51.03%) and 214 female respondents (48.97%). The final section of the questionnaire, which focused on user perceptions, included statements designed to measure each variable based on the constructs, use a 5-point Likert scale as depicted in the Table 2.

Table 1. Demographic Characteristics of Participants

Item	Category	Frequency	Ratio
Gender	Male	223	51.03%
	Female	214	48.97%
Year of study	First	104	23.80%
	Second	116	26.54%
	Third	116	26.54%
	Four	101	23.12%
City	Yogyakarta	28	6.41%
	Kediri	23	5.26%
	Cilacap	23	5.26%
	Tangerang	22	5.03%

Item	Category	Frequency	Ratio
	Jember	21	4.81%
	Jakarta	21	4.81%
	Purwokerto	21	4.81%
	Bogor	19	4.35%
	Blitar	19	4.35%
	Surabaya	19	4.35%
	Semarang	18	4.12%
	Magelang	18	4.12%
	Madiun	17	3.89%
	Pekalongan	17	3.89%
	Depok	17	3.89%
	Bandung	15	3.43%
	Solo	14	3.20%
	Banyumas	14	3.20%
	Tasikmalaya	14	3.20%
	Malang	14	3.20%
	Sukabumi	13	2.97%
	Cirebon	13	2.97%
	Bekasi	13	2.97%
	Banten	12	2.75%
	Probolinggo	12	2.75%
Blended Learning Platform	Google Classroom + Face to face	111	25.40%
	Moodle + Face to face	98	22.43%
	SPADA + Face to face	70	16.02%
	Microsoft Teams + Face to face	57	13.04%
	Canvas + Face to face	37	8.47%
	Zoom LMS + Face to face	28	6.40%
	Schoology + Face to face	19	4.35%
	Edmodo + Face to face	17	3.89%
Duration of Gamification Usage	Less than 1 month	56	12.81%
	1-3 months	94	21.51%
	4-6 months	125	28.60%
	7-12 months	77	17.63%
	More than 1 years	85	19.45%

Table 2. Questionnaire statement

Construct	Definition	Statement	Source
Point	Gamification element in the form of quantitative rewards	Po1. I feel that the number of points I have earned reflects my efforts during the learning process.	[14]

Construct	Definition	Statement	Source
	offered to learners for the completion of tasks or learning activities, serving as performance indicators and motivational triggers	Po2. The number of points awarded helps me understand how well I have completed the tasks. Po3. The number of points I have earned motivates me to complete more tasks. Po4. I understand the purpose of awarding points, and it assists me in achieving learning outcomes.	
Badges	Gamification element in the form of visual or digital symbols awarded as recognition for specific achievements, mastered skills, or positive behaviors in the learning process, thereby fostering a sense of accomplishment and social recognition.	Ba1. I feel that the badges I have earned reflect my achievements in the learning process. Ba2. The badges awarded motivate me to complete tasks more effectively. Ba3. I understand the purpose of awarding badges, and they assist me in achieving learning outcomes.	[14]
Progress bar	Gamification element in the form of visual displays indicating the extent to which learners have completed a series of tasks or learning modules, thereby providing immediate feedback and enhancing motivation to fully engage in the learning process.	Pb1. I feel that the progress bar helps me understand how far I have progressed in completing the learning tasks. Pb2. The progress bar provides clarity regarding my achievements throughout the learning process. Pb3. I feel that the displayed progress bar motivates me to complete all learning tasks. Pb4. The status displayed by the progress bar assists me in evaluating my overall learning progress.	[14]
Leaderboard	Gamification element in the form of leaderboards displaying the ranking of learners based on the	L1. I feel that the leaderboard helps me understand my position in comparison to other participants. L2. The presence of the leaderboard motivates me to complete more tasks in the e-learning environment.	[14]

Construct	Definition	Statement	Source
	accumulation of scores or achievements in the learning process, with the aim of fostering a spirit of competition and enhancing participation.	L3. The presence of the leaderboard encourages me to enhance my learning performance. L4. The presence of the leaderboard increases my enthusiasm for engaging in the learning process.	
Perceived Playfulness	The extent an individual perceives a particular learning experience or interaction as enjoyable, engaging, and entertaining	PP1. I feel that the badges, points, leaderboard, and progress bar provided make the learning process more enjoyable. PP2. Gamification elements (badges, points, leaderboard, and progress bar) enhance my enthusiasm for completing the learning process. PP3. I feel that the badges, points, leaderboard, and progress bar provided make me feel valued, which enhances my enjoyment of the learning process.	[14]
Gamification in blended learning	The incorporation of gamification aspects in educational contexts to augment motivation and engagement, and the outcomes achieved by users.	Ga1. I believe that gamification-based blended learning will enhance interaction compared to conventional learning systems. Ga2. I believe that coursework delivered through gamification-based learning encourages me to engage with it more frequently. Ga3. I am consistently interested in participating in gamified learning activities.	[15]
Motivation to Learn	Internal or external incentives that drive individuals to achieve specific goals.	Mo1. The most satisfying aspect for me is striving to understand the course material as thoroughly as possible. Mo2. The most important aspect for me is to improve my grades and achieve good scores. Mo3. I aspire to achieve a better grade than the majority of my peers in the class. Mo4. I wish to perform well in my class because it is important to demonstrate my abilities to the faculty, family, and peers.	[16]
Learning outcomes	The outcomes or learning achievements attained by students	LO1. The combined application of gamification aspects in e-learning has enhanced my comprehension of the learning material.	[17]

Construct	Definition	Statement	Source
	after completing a learning activity. These outcomes may include improvements in understanding, skills, or other relevant academic achievements.	LO2. I believe my task completion skills have enhanced following the execution of gamified electronic learning. LO3. The combined application of gamification in e-learning positively influences the long-term enhancement of my knowledge and skills.	
Perceived satisfaction	The level of satisfaction experienced by individuals regarding their experiences while using a system or participating in a specific process.	PS1. Overall, I feel satisfied with the learning experience provided through e-learning that incorporates gamification elements. PS2. I would recommend this gamification-based learning to my peers due to the satisfying experience it provides. PS3. Gamification elements make the educational experience more pleasurable and satisfying.	[16]

2.2. Data analysis

The data analysis in this investigation implemented Structural Equation Modelling (SEM) carrying out Partial Least Squares (PLS) through SmartPLS version 4.0 software. PLS-SEM was elected due to its advantages to administer data that do not need to be normally distributed, allowing for the simultaneous use of indicators on both interval and ratio scales, and remaining effective even with relatively small sample sizes. The analysis stages included the creation of a path diagram based on the formulated hypotheses, examination of the measurement model (outer model) and investigation of the structural model (inner model).

To evaluate the relevance of the correlations between the exogenous latent constructs (points, badges, leaderboard, progress bar, perceived playfulness, motivation to learn) and the endogenous latent constructs (perceived satisfaction and learning outcomes), a bootstrap test with 5,000 subsamples was conducted. This bootstrap process was utilized to assess the impact of the relational paths among components based on the path coefficient values (β), t-values, and p-values [18]. The examination of the structural model also included the analysis of the coefficient of determination (R^2) to assess the quantitative value to which the variance of the endogenous constructs can be demonstrated by the exogenous constructs. The outcome of this analysis serves as the basis for drawing conclusions regarding the validity of the research model and the strength of the relationships among the constructs studied in the context of blended learning that integrates gamification.

3. Results and Discussion

The testing of the measurement model was conducted to determine the validity and reliability of the instruments used in the investigation, ensuring that the indicators accurately indicate the constructs being quantified. First, the convergent validity of the reflective constructs was determined by analyzing the Average Variance Extracted (AVE) and Loading Factor values. Based on the analysis results, the loading factor values for all indicators varied between 0.760 and 0.956, beyond the suggested minimum

level threshold of 0.7, signifying that each indicator possesses a robust association with its associated construct. The AVE values for each construct also ranged from 0.687 to 0.872, meeting the minimum requirement of $AVE > 0.5$, which demonstrates that the constructs can clarify above 50% of the variance of their indicators.

The second stage entailed assessing the reliability of the constructs, aimed at measuring the internal consistency among indicators within a single construct. The Cronbach's Alpha (CA) values varied from 0.765 to 0.888, while the Composite Reliability (CR) values differed from 0.848 to 0.941, both higher than the minimum level of 0.7. These outcomes indicate that all constructs possess good internal reliability. Overall, the findings from the measurement model testing demonstrate that the instruments employed in this investigation are both valid and reliable, making them appropriate for subsequent structural model analysis.

Table 3. Loading Factor, AVE, CA, and CR

Constructs	Items	Loading Factors	Average Variance Extracted (AVE)	Cronbach's alpha	Composite reliability
Point	Po1	0.794	0.687	0.848	0.898
	Po2	0.855			
	Po3	0.871			
	Po4	0.792			
Badges	Ba1	0.864	0.790	0.867	0.918
	Ba2	0.918			
	Ba3	0.883			
Progress bar	Pb1	0.760	0.730	0.876	0.915
	Pb2	0.888			
	Pb3	0.883			
	Pb4	0.879			
Leaderboard	L1	0.850	0.851	0.941	0.958
	L2	0.936			
	L3	0.956			
	L4	0.943			
Perceived playfulness	PP1	0.924	0.847	0.909	0.943
	PP2	0.940			
	PP3	0.896			
Gamification in e-learning	Ga1	0.924	0.872	0.926	0.953
	Ga2	0.932			
	Ga3	0.945			
Motivation to learn	Mo1	0.823	0.707	0.862	0.906
	Mo2	0.771			
	Mo3	0.881			
	Mo4	0.883			
Learning outcomes	LO1	0.904	0.816	0.887	0.930
	LO2	0.876			
	LO3	0.930			

This study evaluated discriminant validity using the Fornell-Larcker criterion, which contrasts the square root of the Average Variance Extracted (AVE) values for each construct against the correlations of the other components. The analysis results, as demonstrated by Table 4, illustrate that all square root AVE values exceed the correlation values between each construct in the corresponding rows and columns. The construct of Perceived Playfulness has a square root AVE value of 0.920, which exceeds its highest correlation of 0.788 with the construct of Leaderboard. Similarly, the construct of

Gamification in E-learning has a square root AVE of 0.934, and the Learning Outcomes construct has a square root AVE of 0.903. These findings suggest that each construct within the model possesses good discriminative ability and effectively represents distinct conceptual dimensions, thereby satisfying the requirements for discriminant validity necessary in PLS-SEM structural modeling for research in the domain of educational technology.

Table 4. Fornell-Larcker criterion

	Ba	Ga	L	LO	Mo	PS	PP	Po	Pb
Ba	0.889								
Ga	0.682	0.934							
L	0.766	0.557	0.922						
LO	0.611	0.674	0.583	0.903					
Mo	0.502	0.513	0.479	0.480	0.841				
PS	0.675	0.763	0.576	0.701	0.646	0.907			
PP	0.792	0.713	0.788	0.669	0.634	0.758	0.920		
Po	0.783	0.753	0.587	0.674	0.426	0.635	0.678	0.829	
Pb	0.768	0.630	0.643	0.548	0.588	0.668	0.708	0.679	0.854

Note: Po = Point, Ba = Badges, Pb = Progress bar, L = leaderboard, PP = Perceived playfulness, Ga = Gamification in e-learning, Mo = Motivation to learn, LO = Learning Outcomes, PS Perceived Satisfaction

The figure indicates the outcome of the Heterotrait-Monotrait Ratio of Correlations (HTMT) test as part of the evaluation of discriminant validity among constructs in the research model. The HTMT test is employed to assess the level to which a construct is empirically differentiated from other constructs, with the criterion that HTMT values are required to be beneath the threshold of 0.90 to indicate acceptable discriminant validity [19]. Based on the analysis results, nearly all construct pairs exhibited HTMT values below 0.90, except for the relationship between Points and Badges (HTMT = 0.910), which slightly exceeds the threshold. Nevertheless, the overall results remain within an acceptable tolerance range in the context of social and consumer behavior, particularly because the constructs of Points and Badges theoretically share similarities as components of gamification elements. Therefore, the model can still be considered to possess good discriminant validity, and the developed constructs can be utilized to measure distinct concepts in the study of gamification in blended learning environments.

Table 5. Heterotrait-Monotrait Ration (HTMT)

	Ba	Ga	L	LO	Mo	PS	PP	Po	Pb
Ba									
Ga	0.758								
L	0.847	0.598							
LO	0.687	0.736	0.623						
Mo	0.568	0.556	0.525	0.538					
PS	0.764	0.837	0.621	0.784	0.719				

PP	0.890	0.777	0.847	0.738	0.707	0.839		
Po	0.910	0.849	0.653	0.776	0.483	0.727	0.771	
Pb	0.875	0.693	0.706	0.609	0.670	0.746	0.792	0.776

Note: Po = Point, Ba = Badges, Pb = Progress bar, L = leaderboard, PP = Perceived playfulness, Ga = Gamification in e-learning, Mo = Motivation to learn, LO = Learning Outcomes, PS Perceived Satisfaction

The evaluation of the coefficient of determination (R^2) in this research model indicates varying levels of predictive capability, ranging from moderate to high. The construct of Perceived Playfulness exhibits the highest R^2 value of 0.759, signifying that a significant portion of its variance can be elucidated by the incorporated gamification components, such as points, badges, leaderboard, and progress bar. Furthermore, Perceived Satisfaction and Progress Bar also demonstrate high R^2 values of 0.679 and 0.695, respectively, reflecting the significant influence of user motivation and interactive perceptions within the blended learning system. The constructs of Leaderboard and Learning Outcomes have R^2 values of 0.588 and 0.454, respectively, indicating the model's contribution to explaining perceptions of competition and learning outcomes. Meanwhile, the construct of Motivation to Learn records the lowest R^2 value of 0.264, suggesting that the variables within the model account for only a small portion of the variance in learning motivation, thereby opening avenues for the exploration of additional external factors in future research. Overall, these R^2 values affirm the structural strength of the model in understanding the dynamics of the influence of gamification on motivation and educational results within the context of blended learning.

Table 6. Coefficient of Determination

Construct	R Square	R Square Adjust
Leaderboard	0.588	0.586
Learning outcomes	0.454	0.453
Motivation to learn	0.264	0.262
Perceived satisfaction	0.679	0.676
Perceived playfulness	0.759	0.757
Progress bar	0.695	0.604

The outcomes of the path analysis employing bootstrapping methodologies with 5,000 resamples in PLS-SEM indicate that the majority of the relationships among constructs in the research model are statistically significant. For instance, the relationship among Badges and Leaderboard ($\beta = 0.792$, $t = 15.494$, $p < 0.001$) and Progress Bar ($\beta = 0.610$, $t = 12.065$, $p < 0.001$) demonstrates a very strong and significant influence. Similarly, Gamification in E-learning significantly affects Learning Outcomes ($\beta = 0.674$, $t = 18.617$) and Motivation to Learn ($\beta = 0.513$, $t = 10.855$). Additionally, Perceived Playfulness significantly influences Perceived Satisfaction ($\beta = 0.383$, $t = 9.360$), while both Leaderboard and Progress Bar also show a positive contribution to Perceived Playfulness. However, the path from Points to Leaderboard ($\beta = -0.033$, $p = 0.573$) is not significant, indicating that points as a gamification element do not have a meaningful impact on students' perceptions of competition within the leaderboard. Overall, these outcomes reinforce the validity of the proposed structural model and demonstrate that gamification elements, particularly badges, leaderboards, and perceived playfulness, perform an essential function in shaping motivation and learning outcomes in blended learning environments. Decisions regarding the acceptance or rejection of hypotheses were made based on p-values. A hypothesis is classified as "rejected" if the p-value exceeds the significance level of 0.05. A hypothesis is classified as "accepted" if the p-value is not exceeding 0.05. According to the analysis results presented in Table 7, out of a total of 14 tested hypotheses, 12 were accepted, while 2 were rejected.

Table 7. Testing of the Structural Model Hypotheses

Hypothesis	Param	Original Sample	Sample Mean	Standard Deviation	T Statistics	P Values	Status
H1a	Po -> Pb	0.202	0.199	0.057	3.547	0.000	Accepted
H1b	Ba -> Pb	0.610	0.609	0.051	12.065	0.000	Accepted
H2a	Po -> L	-0.033	-0.032	0.059	0.564	0.573	Rejected
H2b	Ba -> L	0.792	0.788	0.051	15.494	0.000	Accepted
H3a	Po -> PP	-0.023	-0.023	0.061	0.378	0.705	Rejected
H3b	Ba -> PP	0.220	0.217	0.065	3.363	0.001	Accepted
H4a	Pb -> PP	0.122	0.124	0.040	3.058	0.002	Accepted
H4b	L -> PP	0.397	0.394	0.051	7.719	0.000	Accepted
H5	Ga -> PP	0.283	0.288	0.048	5.951	0.000	Accepted
H6	Ga -> LO	0.674	0.674	0.036	18.617	0.000	Accepted
H7	Ga -> Mo	0.513	0.515	0.047	10.855	0.000	Accepted
H8	PP -> PS	0.383	0.384	0.041	9.350	0.000	Accepted
H9	LO -> PS	0.327	0.331	0.051	6.444	0.000	Accepted
H10	Mo -> PS	0.246	0.240	0.043	5.666	0.000	Accepted

Note: Po = Point, Ba = Badges, Pb = Progress bar, L = leaderboard, PP = Perceived playfulness, Ga = Gamification in e-learning, Mo = Motivation to learn, LO = Learning Outcomes, PS = Perceived Satisfaction

This investigation's outcomes indicate that not all gamification aspects exert an equivalent influence on student motivation, playfulness, and learning outcomes in blended learning environments. Badges were found to exert the most dominant influence on the leaderboard and progress bar, and they indirectly enhance perceived playfulness and perceived satisfaction. These findings support the studies by [20] and [21], which assert that visual reward symbols, such as badges, possess high emotional value and can strengthen learners' feelings of achievement.

Conversely, points, as a quantitative gamification element, did not demonstrate a significant effect on the leaderboard or perceived playfulness. This aligns with the findings of [15], which highlight the novelty effect in gamification, where certain elements lose their appeal if not integrated into a meaningful learning context. This underscores the necessity of considering the aspects of meaningful gamification [22], which involves the application of game elements that are not only visually appealing but also pedagogically and emotionally relevant.

Overall, gamification shows a substantial and meaningful link with learning outcomes ($\beta = 0.674$) and motivation to learn ($\beta = 0.513$), supporting the meta-analyses by [23], which conclude that gamification can enhance cognitive and affective engagement. In the context of blended learning, which demands higher learning autonomy, game elements that promote self-regulation, clarity of goals, and structured feedback are crucial for maintaining sustained student engagement [1,24].

The finding that perceived playfulness mediates the relationship between perceived satisfaction contributes significantly to the theoretical development of motivation models focusing on Self-Determination Theory. Enjoyable and immersive learning experiences create psychological conditions that support intrinsic engagement, learning satisfaction, and long-term material retention [25]. Thus, gamification is not merely a technical approach but a pedagogical strategy that addresses affective and social aspects of the learning process.

The practical ramifications of this research are significantly pertinent for developers of digital learning systems. Instructional designers need to be more selective in choosing and integrating

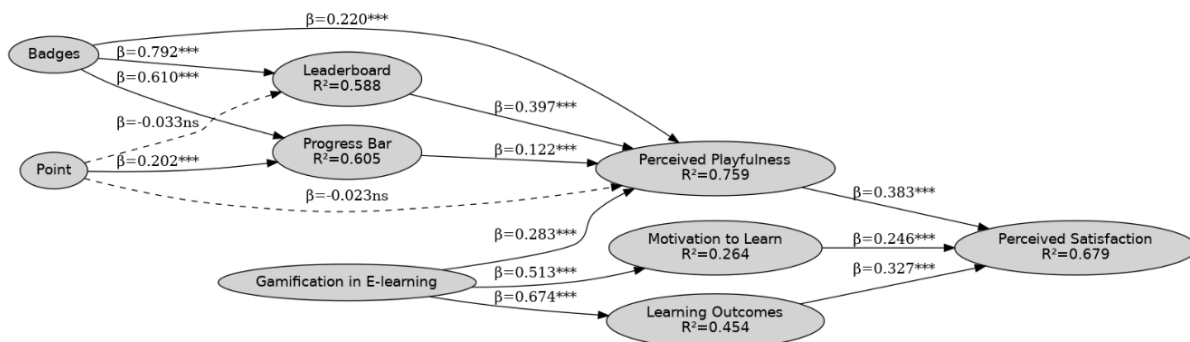
gamification elements. Badges, progress bars, and leaderboards that are designed adaptively and visually have proven to be more effective compared to points, which tend to be repetitive and less personal. Furthermore, it is essential to avoid information overload, which can disrupt the perception of enjoyable learning experiences [16].

As illustrated in Figure 2, this study empirically demonstrates that 75.9% of the variance in Perceived Playfulness can be explained by the combined influence of leaderboards, badges, points, progress bars, and perceptions of gamification in e-learning. Similarly, 67.9% of the variance in Perceived Satisfaction is influenced by Motivation to Learn, Perceived Playfulness, and Learning Outcomes.

Additionally, the model accounts for 58.8% of the variation in the Leaderboard and 60.5% in the Progress Bar, which are primarily influenced by the mechanisms of badges and points. Badges consistently show a strong and significant contribution across various pathways (e.g., $\beta = 0.792^{***}$ for Leaderboard and $\beta = 0.610^{***}$ for Progress Bar), whereas the points element demonstrates a weaker or non-significant influence (e.g., $\beta = -0.033ns$ for Leaderboard and $\beta = -0.023ns$ for Playfulness).

The model also indicates that 45.4% of Learning Outcomes and 26.4% of Motivation to Learn are significantly influenced by gamification mechanisms. Notably, Gamification in E-learning has a strong path coefficient regarding Learning Outcomes ($\beta = 0.674^{***}$) and Motivation to Learn ($\beta = 0.513^{***}$), thereby reinforcing the position of gamification as a primary factor driving student engagement and academic success. Overall, these discoveries serve as confirmation of the power of the proposed structural model and emphasize the importance of effective gamification design in enhancing motivation, engagement, and learning satisfaction within blended learning environments.

Future study should employ a longitudinal methodology to determine the long-term impacts of gamification, consider mediating variables such as self-efficacy and digital literacy, test cross-level and educational context models, compare the effectiveness of platforms with and without gamification, and explore potential psychological risks to create more adaptive, sustainable, and student-well-being-oriented digital learning systems.



Notes: Rejected hypotheses are indicated by dotted arrows, while significant relationships are indicated by solid arrows.

*** $p < 0.001$

Figure 2. Finalized Research Model

From the perspective of higher education policy, these findings encourage institutions to develop user experience-oriented digital learning strategies. Faculty training and the development of e-learning platforms should focus on the contextual integration of gamification, not only to enhance motivation but also to foster digital literacy and learning autonomy [26,27]. In the long term, this approach can improve learning satisfaction, reduce dropout rates, and expand access to quality technology-based education.

4. Conclusion

This study empirically validates a structural model explaining how key gamification elements—badges, points, progress bars, and leaderboards—affect learning motivation, perceived playfulness, learning outcomes, and learning satisfaction in blended learning environments. The findings reveal that badges are the most influential element, significantly shaping learners' perceptions of progress and competition through their relationship with progress bars and leaderboards, while points show relatively limited impact. The study also highlights the crucial mediating role of perceived playfulness in connecting gamification experiences with learning satisfaction, consistent with the principles of Self-Determination Theory, which emphasizes competence, relatedness, and autonomy. Practically, the results suggest that effective gamification depends not only on the presence of game features but also on how meaningfully they are integrated into instructional design, with visually interactive and feedback-oriented elements such as badges and progress bars being more impactful than abstract elements like points. Overall, gamification can significantly enhance motivation, engagement, learning outcomes, and satisfaction when implemented strategically within learner-centered digital learning environments.

Declaration of AI and AI assisted technologies in the writing process

During the preparation of this manuscript, the authors used ChatGPT to assist in improving language quality, grammar checking, sentence structuring, and enhancing the clarity of academic writing. All generated outputs were carefully reviewed, revised, and validated by the authors. The authors take full responsibility for the final content of this publication.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors would like to extend their sincere appreciation to all student participants who willingly engaged in this study. Their valuable time, honest responses, and willingness to share their learning experiences made a substantial contribution to the success of this research. The insights provided by the respondents have been instrumental in understanding the importance of gamification in blended learning environments. Furthermore, the authors are deeply grateful to Lembaga Penelitian dan Pengabdian Masyarakat (LP2M) Universitas Pembangunan Nasional "Veteran" Jakarta for providing financial support and funding through the Scopus-based Research Grant (RISCOP). This research would not have been possible without their support and commitment to advancing academic excellence.

References

- [1] Simsek E, Karakus Yilmaz T. A Systematic Review of the Effects of Gamification in Online Learning Environments on Learning Outcomes. *Open Praxis* 2025;17. <https://doi.org/10.55982/openpraxis.17.1.692>.
- [2] Theresiawati T, Seta HB, Arista A. Implementing quality function deployment using service quality and Kano model to the quality of e-learning. *International Journal of Evaluation and Research in Education* 2023;12:1560. <https://doi.org/10.11591/ijere.v12i3.25511>.
- [3] Bayu Seta H, - T, Afrizal S, Nizar Hidayanto A. Analysis of a Mobile Learning Adoption Model for Learning Improvement Based on Students' Perception. *Journal of Information Technology Education: Research* 2022;21:169–96. <https://doi.org/10.28945/4955>.
- [4] Lampropoulos G, Sidiropoulos A. Impact of Gamification on Students' Learning Outcomes and Academic Performance: A Longitudinal Study Comparing Online, Traditional, and Gamified Learning. *Education Sciences (Basel)* 2024;14:367. <https://doi.org/10.3390/educsci14040367>.

- [5] Ayaz A, Özyurt Ö, Al-Rahmi WM, Salloum SA, Shutaleva A, Alblehai F, et al. Exploring Gamification Research Trends Using Topic Modeling. *IEEE Access* 2023;11:119676–92. <https://doi.org/10.1109/access.2023.3326444>.
- [6] Subiyantoro S, Degeng INS, Kuswandi D, Ulfa S. Developing Gamified Learning Management Systems to Increase Student Engagement in Online Learning Environments. *International Journal of Information and Education Technology* 2024;14:26–33. <https://doi.org/10.18178/ijiet.2024.14.1.2020>.
- [7] Bouchrika I, Harrati N, Wanick V, Wills G. Exploring the Impact of Gamification on Student Engagement and Involvement with e-learning Systems. *Interactive Learning Environments* 2019;29:1–14. <https://doi.org/10.1080/10494820.2019.1623267>.
- [8] Ukgoda H. Gamification in Education: Its Impact on Engagement, Motivation, and Learning Outcomes. *OrcidOrg* 2025.
- [9] Ahma G, Kadriu A. Exploring the Impact of Gamification Strategies on Student Engagement and Learning Outcomes in Education. 2025 20th Annual System of Systems Engineering Conference (SoSE) 2025:1–6. <https://doi.org/10.1109/sose66311.2025.11083792>.
- [10] Ferdiansyah H, Rafi MF, Utama AP, Aprilia T, Slamet J. Assessing learning outcomes and self-directed learning through gamification in LMS. *Social Sciences & Humanities Open* 2025;12:101696. <https://doi.org/10.1016/j.ssaho.2025.101696>.
- [11] Yang Y, Yu A, Li J, Shafi M, Fauzi MA. Exploring the impact of gamified elements on college students' learning in virtual learning communities. *Kybernetes* 2024. <https://doi.org/10.1108/k-01-2024-0017>.
- [12] Seta HB, Theresiawati T, Niqotaini Z, Trahira JI, Assegaf NN. Push-Pull-Mooring Theory and The Moderating Effect of Inertia on Switching Intention to Mobile Learning. *JOIV : International Journal on Informatics Visualization* 2025;9:1881. <https://doi.org/10.62527/joiv.9.5.2867>.
- [13] Ramírez-Donoso L, Pérez-Sanagustín M, Neyem A, Alario-Hoyos C, Hilliger I, Rojos F. Fostering the use of online learning resources: results of using a mobile collaboration tool based on gamification in a blended course. *Interactive Learning Environments* 2023;31:1564–78. <https://doi.org/10.1080/10494820.2020.1855202>.
- [14] Fajri FA, Haribowo P, RYK, Amalia N, Natasari D. Gamification in E-Learning: The Mitigation Role in Technostress. *International Journal of Evaluation and Research in Education* 2021;10:606–14.
- [15] Rodrigues L, Pereira FD, Toda AM, Palomino PT, Pessoa M, Carvalho LSG, et al. Gamification suffers from the novelty effect but benefits from the familiarization effect: Findings from a longitudinal study. *International Journal of Educational Technology in Higher Education* 2022;19. <https://doi.org/10.1186/s41239-021-00314-6>.
- [16] Hebbbar S, Manohar S, Hungund S. Examining gamification's impact on perceived satisfaction through learning parameters: a preliminary perception-based study among prospective users. *Interactive Learning Environments* 2024:1–20. <https://doi.org/10.1080/10494820.2024.2417719>.
- [17] Shen Z, Lai M, Wang F. Investigating the influence of gamification on motivation and learning outcomes in online language learning. *Frontiers in Psychology* 2024;15. <https://doi.org/10.3389/fpsyg.2024.1295709>.
- [18] Hair JF, Babin BJ, Ringle CM, Sarstedt M, Becker J-M. Covariance-based structural equation modeling (CB-SEM): a SmartPLS 4 software tutorial. *Journal of Marketing Analytics* 2025. <https://doi.org/10.1057/s41270-025-00414-6>.
- [19] Ramírez A, Burgos-Benavides L, Sinchi H, Quito-Calle JV, Herrero Díez F, Rodríguez-Díaz FJ. Adaptation and Validation of Psychological Assessment Questionnaires Using Confirmatory Factor Analysis: A Tutorial for Planning and Reporting Analysis. *PreprintsOrg* 2025. <https://doi.org/10.20944/preprints202502.1192.v1>.
- [20] Sai V, Meesala L, Shaik A, Adloori H. The Impact of Virtual Achievements on Online Learning Applications. *ArXiv (Cornell University)* 2024. <https://doi.org/10.48550/arxiv.2409.05877>.

- [21] Mellado R, Cubillos C, Vicari RM, Gasca-Hurtado G. Leveraging Gamification in ICT Education: Examining Gender Differences and Learning Outcomes in Programming Courses. *Applied Sciences* 2024;14:7933. <https://doi.org/10.3390/app14177933>.
- [22] Mohammed YB, Ozdamli F. Motivational Effects of Gamification Apps in Education: A Systematic Literature Review. *BRAIN Broad Research in Artificial Intelligence and Neuroscience* 2021;12:122–38.
- [23] Huseinović L. The Effects of Gamification On Student Motivation And Achievement In Learning English As A Foreign Language In Higher Education. *MAP Education and Humanities* 2023;4:10–36. <https://doi.org/10.53880/2744-2373.2023.4.10>.
- [24] Firwana A, Abu Shouqer M, Aqel M. Effectiveness of E-learning Environments in Developing Skills for Designing E-tivities Based on Gamification for Teachers of Technology in Gaza. *Education in the Knowledge Society (EKS)* 2021;22:e23907. <https://doi.org/10.14201/eks.23907>.
- [25] Poupard M, Larrue F, Sauzéon H, Tricot A. A systematic review of immersive technologies for education: Learning performance, cognitive load and intrinsic motivation. *British Journal of Educational Technology* 2024. <https://doi.org/10.1111/bjet.13503>.
- [26] Galani ME. Enhancing engagement in asynchronous eLearning: A Gamified Pedagogical Framework. *INCLUSIVE* 2025:77.
- [27] Ramalingam S, Yunus MM, Hashim H. Blended Learning Strategies for Sustainable English as a Second Language Education: A Systematic Review. *Sustainability* 2022;14:8051. <https://doi.org/10.3390/su14138051>.