Journal of Applied Engineering and Technological Science
Vol 7(2) 2026: 943-959

LINKING GAMIFICATION TECHNOLOGY, MOTIVATION, AND FLOW TO STUDENT ENGAGEMENT AND PROBLEM-SOLVING IN EDUCATION

Dedy Irfan[1]*, Didik Hariyanto[2], Heri Prabowo[3], Zulhendra[4], Edidas[5], Andhika Herayono[6]
Department of Electronics Engineering, Universitas Negeri Padang, Air Tawar, Kota Padang, 25171, Indonesia[1,4,5,6]
Faculty of Engineering, Universitas Negeri Yogyakarta, Sleman, Daerah Istimewa Yogyakarta 55281, Indonesia[2]
Department of Mining Engineering, Universitas Negeri Padang, Air Tawar, Kota Padang, 25171, Indonesia[3]

Received: 26 November 2025, Revised: 10 March 2026, Accepted: 04 April 2026
**Corresponding Author*

ABSTRACT
The use of gamification in higher education has been widely explored as a strategy to enhance student engagement and learning outcomes. However, many empirical studies on gamified learning primarily examine direct relationships between gamification and motivational outcomes, while the underlying experiential mechanisms that connect gamification with sustained engagement and higher-order cognitive performance remain insufficiently understood. In particular, few structural modeling studies simultaneously examine the roles of motivation, flow, and presence within a unified experiential framework. This study investigates how gamification technology influences student engagement and problem-solving competence through the experiential mechanisms of motivation, flow, and presence. A quantitative research design was employed involving 100 undergraduate students enrolled in technology-oriented programs (electronics engineering education and informatics engineering education) at Universitas Negeri Padang. Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) to examine the proposed mediation pathways. The results indicate that gamification technology significantly influences motivation ($\beta = 0.412, p < 0.001$), flow ($\beta = 0.508, p < 0.001$), and presence ($\beta = 0.436, p < 0.001$). Among the experiential constructs, flow shows the strongest influence on student engagement ($\beta = 0.483, p < 0.001$), while the effect of motivation on engagement is not statistically significant ($\beta = 0.097, p = 0.18$). Student engagement subsequently demonstrates a significant effect on problem-solving competence ($\beta = 0.498, p < 0.001$). The structural model explains 30.6% of the variance in student engagement and 24.8% of the variance in problem-solving competence. These findings suggest that immersive experiential states, particularly flow, play an important role in shaping engagement in gamified learning environments. The study contributes to the gamification literature by proposing and empirically testing an experiential pathway model that integrates psychological immersion mechanisms with behavioral learning outcomes in technology-enhanced education.

Keywords : *Gamification Technology, Motivation, Flow, Presence, Student Engagement, Problem Solving, PLS-SEM, Experiential Learning*

1. Introduction

The integration of gamification in higher education has gained increasing attention as institutions seek instructional approaches capable of fostering deeper student engagement and active learning (Nuringsih & Nuryasman, 2021) (C. Wang et al., 2020). In technology-oriented disciplines such as engineering education, computer science, and vocational technology education, learning often requires sustained cognitive effort, analytical reasoning, and complex problem-solving abilities. Traditional lecture-based instruction frequently struggles to maintain student motivation and engagement in these domains, particularly when learners must interact with abstract technical concepts and analytical tasks. As a result, educators have increasingly explored gamification as a pedagogical strategy to transform passive learning environments into interactive systems that stimulate persistence, curiosity, and voluntary participation (Julieth et al., 2024) (Christopoulos & Sprangers, 2021).

Gamification refers to the integration of game design elements such as points, levels, rewards, challenges, and feedback mechanisms into non-game learning environments in order to enhance learner motivation and engagement (Bai et al., 2026) (Zhao et al., 2025). In educational contexts, gamification supports experiential learning by enabling students to interact with structured challenges and receive immediate feedback during the learning process (Wolf et al., 2025) (Jeong, 2025). Recent empirical studies indicate that gamified learning environments can significantly improve behavioral engagement, persistence, and learning performance compared to conventional instructional approaches (Ratinho, 2023) .These benefits are particularly relevant in technology-enhanced learning environments where students must actively apply knowledge rather than passively receive information (Tasrif et al., 2024) (Kim, 2019).

Despite the increasing adoption of gamification in education, the mechanisms through which gamification influences meaningful learning outcomes remain insufficiently understood. Many existing studies continue to evaluate gamification primarily through surface-level outcomes such as motivation, enjoyment, or perceived usefulness. Although these findings demonstrate the positive reception of gamified learning systems, they often overlook the internal psychological processes that occur during the learning experience. Consequently, gamification is frequently modeled as having a direct influence on engagement or learning outcomes without considering the experiential mechanisms that mediate this relationship (Gini et al., 2025) (Chukwu et al., 2024).

Recent developments in immersive learning research suggest that learning behavior is shaped by a sequence of internal psychological transitions rather than by technological features alone (Schweder et al., 2025). When learners interact with gamified learning environments, initial curiosity may stimulate motivation, which can subsequently evolve into deeper states of cognitive immersion known as flow. As learners become increasingly absorbed in the activity, they may also experience a stronger sense of presence, defined as the psychological perception of being “inside” the learning environment rather than interacting with it externally (Schweder et al., 2025) (Vansteenkiste et al., 2020). These experiential states collectively shape the level of engagement that ultimately determines learning outcomes.

Flow, originally conceptualized by Csikszentmihalyi (1990), refers to a state of deep cognitive immersion in which individuals become fully absorbed in a task and lose awareness of external distractions. In digital learning environments, flow has been identified as a key predictor of sustained engagement and learning persistence (Bassner et al., 2026) (Joshi & Desai, 2020). Presence, on the other hand, reflects the psychological sense of immersion within a mediated environment and plays a critical role in immersive digital learning experiences (Willy et al., 2025). Recent studies indicate that presence enhances attentional commitment and emotional involvement, thereby supporting sustained participation during learning activities (Salido et al., 2025). Together, motivation, flow, and presence represent experiential constructs that shape how learners interact with gamified learning environments.

Although these constructs have been widely discussed in educational technology literature, most existing structural modeling studies on gamification examine only partial relationships among them. Many studies focus primarily on the relationship between gamification and motivation or between gamification and engagement, while overlooking deeper experiential mechanisms that occur during the learning process (Jaramillo-mediavilla et al., 2024). In particular, very few empirical studies have simultaneously examined flow and presence as sequential mediators within a unified structural framework. This limitation creates an important research gap in understanding how gamification leads not only to positive perceptions but also to sustained engagement and higher-order learning outcomes.

This research gap is particularly relevant in engineering and technology education, where the development of problem-solving competence represents a central learning objective. Students in these fields are expected not only to understand theoretical concepts but also to apply knowledge in complex and dynamic problem situations. However, problem-solving competence cannot emerge solely from exposure to instructional content. Instead, it requires sustained engagement, cognitive persistence, and active interaction with learning tasks. Understanding the experiential mechanisms that connect gamified learning environments with problem-solving performance is therefore essential for designing more effective instructional technologies (Anwar et al., 2024) (Ting et al., 2024).

To address this gap, the present study proposes an experiential pathway model that explains how gamification technology influences student engagement and problem-solving competence through a sequence of psychological mechanisms. In this model, Gamification Technology functions as the instructional stimulus that triggers learners' motivation and immersive learning experiences (Balalle, 2024) (Vansteenkiste et al., 2020). These experiential states subsequently foster Student Engagement, which serves as the behavioral mechanism through which learners translate immersive participation into cognitive performance. Ultimately, this engagement contributes to the development of Problem-Solving competence, which represents a key educational outcome in technology-oriented learning environments (Chukwu et al., 2024) (Grigore, 2026).

The novelty of this study lies in three main contributions. First, from a theoretical perspective, the study proposes an experiential pathway model that conceptualizes gamification as a sequence of psychological transitions rather than as a direct instructional intervention. Second, from a methodological perspective, the study employs Partial Least Squares Structural Equation Modeling (PLS-SEM) to examine multiple mediation pathways among experiential constructs (M. Wang & Zhang, 2026) (Hair et al., n.d.). Third, from a contextual perspective, the research investigates these mechanisms within a technology-enhanced learning environment in higher education, where problem-solving competence is an essential learning outcome.

Based on these considerations, the study addresses the following research question:

RQ: How does gamification technology influence student engagement and problem-solving competence through the experiential mechanisms of motivation, flow, and presence?

To empirically test the proposed model, the following hypotheses are formulated:

H1: Gamification Technology positively influences Motivation.
H2: Gamification Technology positively influences Flow.
H3: Gamification Technology positively influences Presence.
H4: Motivation positively influences Student Engagement.
H5: Flow positively influences Student Engagement.
H6: Presence positively influences Student Engagement.
H7: Student Engagement positively influences Problem-Solving competence.

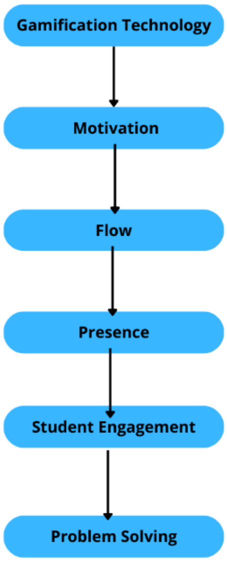


Fig. 1. Proposed Experiential Model of Gamified Learning

By examining these relationships using Structural Equation Modeling (SEM-PLS), this study aims to provide a more comprehensive explanation of how gamification influences learning behavior and cognitive outcomes. The findings are expected to contribute to the gamification literature by clarifying the experiential mechanisms that connect gamified instructional design with meaningful educational performance in technology-oriented learning environments.

2. Literature Review and Hypothesis Development

Gamification has become an increasingly prominent instructional strategy in technology-enhanced learning environments. Gamification refers to the integration of game design elements such as points, challenges, rewards, and feedback systems into non-game contexts in order to enhance user engagement and motivation (Grigore, 2026). In educational contexts, gamification transforms traditional learning activities into interactive experiences that encourage learners to actively participate in tasks rather than passively receive information. This approach is particularly relevant in engineering and technology education, where students are expected to apply conceptual knowledge to complex problem-solving situations (Gini et al., 2025).

Recent empirical research indicates that gamified learning environments can significantly enhance engagement and learning persistence, demonstrated that gamification-enhanced learning systems improved behavioral and cognitive engagement among university students. Similarly, found that immersive digital environments strengthen cognitive involvement when learners interact with interactive tasks. Systematic reviews further confirm that gamification positively influences student motivation, engagement, and academic outcomes across various educational contexts (Ratinho, 2023).

However, despite these promising findings, previous research has reported inconsistent results regarding the mechanisms through which gamification influences learning outcomes. Many studies focus primarily on motivation as the main explanatory variable, assuming that increased motivation will automatically translate into engagement and performance. Yet empirical evidence suggests that motivational effects alone may decline over time when learners do not experience deeper cognitive immersion during the learning process (Daumiller & Meyer, 2026). These findings indicate that additional experiential constructs may play a critical mediating role in explaining the effectiveness of gamified learning environments.

a. Theoretical Foundations of Experiential Learning

The theoretical foundation of this study is grounded in three major theoretical perspectives: Self-Determination Theory, Flow Theory, and Experiential Learning Theory. Self-Determination Theory explains how learners' motivation develops when learning environments satisfy psychological needs for autonomy, competence, and relatedness (C. Wang et al., 2020).Gamified systems often support these needs by providing feedback mechanisms, reward structures, and opportunities for learners to control their learning progress.

Flow Theory describes a psychological state in which individuals become fully immersed in an activity, experiencing deep concentration and intrinsic enjoyment (Schweder et al., 2025) (Vansteenkiste et al., 2020). Flow occurs when the difficulty of a task is balanced with the learner's skill level, allowing sustained cognitive engagement during the activity. Experiential Learning Theory emphasizes that meaningful learning occurs when learners actively interact with tasks and reflect on their experiences. Gamified learning environments create interactive experiences that allow learners to actively engage with learning tasks, thereby facilitating experiential learning processes.

Together, these theoretical perspectives explain how gamification can stimulate psychological states such as motivation, flow, and presence, which subsequently influence engagement and learning outcomes.

b. Empirical Models of Gamification in Learning Research

Several empirical studies have attempted to explain the impact of gamification using structural modeling approaches. Many models examine relationships such as gamification → motivation → engagement or gamification → engagement → learning performance. These models provide valuable insights into the motivational impact of gamified learning systems but often neglect deeper experiential states that occur during the learning process. For instance, some studies have examined the role of motivation and engagement as mediating mechanisms in gamified learning environments (Zuo et al., 2025) (Wu et al., 2026).Other research has explored the relationship between flow and engagement in digital learning contexts (Oliveira et al., 2023). However, relatively few studies have simultaneously integrated flow and presence within a unified structural framework. This limitation is significant because flow and presence represent different dimensions of immersion. Flow describes immersion in the activity itself, while presence refers to immersion in the learning environment. Without integrating both constructs simultaneously, existing models may oversimplify the experiential dynamics of gamified learning.

c. Operationalization of Experiential Constructs

Previous studies have operationalized these experiential constructs using validated measurement indicators. Motivation is commonly measured through learners' interest, willingness to participate, and perceived meaningfulness of learning activities (Stöhr et al., 2020). Flow is typically operationalized through indicators such as deep concentration, cognitive absorption, and loss of time awareness during tasks. Presence is measured through perceptions of immersion, realism, and psychological involvement in digital environments (Ozdamar-Keskin et al., 2020). Student engagement is often assessed through behavioral indicators such as active participation, persistence, and effort during learning activities (C. Wang et al., 2020). Finally, problem-solving competence is operationalized through learners' ability to analyze problems, apply strategies, and evaluate solutions (Todd & Zhang, 2020). Integrating these constructs within a single structural model allows researchers to examine how experiential learning states translate into observable behavioral engagement and cognitive outcomes.

As shown in Table 1, the constructs used in this study represent different psychological dimensions of experiential learning that collectively influence student engagement and problem-solving performance.

Table 1 - Summary of Key Constructs in Gamified Learning

Construct	Core Concept	Psychological Mechanism	Key References
Gamification Technology	Game-based instructional design integrating rewards, challenges, and feedback	Stimulates learner participation and readiness	(Grigore, 2026) (Balalle, 2024)
Motivation	Internal drive that encourages participation in learning tasks	Initiates behavioral intention and persistence	(Daumiller & Meyer, 2026) (Bassner et al., 2026)
Flow	State of deep cognitive immersion in an activity	Sustains concentration and intrinsic engagement	(Sorongan et al., 2021) (K. Wang et al., 2026)v
Presence	Psychological perception of being immersed in the learning environment	Strengthens emotional involvement and attention	(Schweder et al., 2025) (Vansteenkiste et al., 2020)v
Student Engagement	Behavioral manifestation of cognitive and emotional involvement	Translates psychological states into active participation	(Aini et al., 2013) (Ye et al., 2024)
Problem-Solving	Higher-order cognitive ability to analyze and resolve problems	Applies knowledge to complex tasks	(Anwar et al., 2024) (Nathaniel et al., 2025) (Otto et al., 2025)

d. Hypothesis Development

1. Gamification Technology and Motivation

Gamification technology can stimulate learners' motivation by introducing reward systems, progress indicators, and interactive challenges that reinforce learners' sense of competence and achievement. According to Self-Determination Theory, such mechanisms support intrinsic motivation by satisfying learners' psychological needs for autonomy and competence (Vansteenkiste et al., 2020). Empirical studies have demonstrated that gamified learning systems significantly increase students' willingness to participate in learning activities (Stöhr et al., 2020).

H1: Gamification Technology positively influences Motivation.

2. **Gamification Technology and Flow**
   Gamification can also induce flow experiences by providing structured challenges that balance difficulty and skill level. Interactive mechanics such as progressive difficulty and real-time feedback help maintain learners' concentration and cognitive immersion during learning activities. Empirical studies have shown that game-based learning environments significantly enhance flow experiences among learners (Aslan et al., 2025) (Piquer-martinez et al., 2025).
   H2: Gamification Technology positively influences Flow.

3. **Gamification Technology and Presence**
   Presence reflects learners' perception of being psychologically immersed in a digital environment. Unlike flow, which focuses on cognitive absorption in the task, presence captures the learner's sense of "being inside" the learning environment. Gamified learning systems often incorporate visual feedback, interactive interfaces, and immersive elements that strengthen learners' sense of presence. Research in immersive learning environments suggests that presence significantly enhances learner involvement and attention (Chukwu et al., 2024) (Grigore, 2026).
   H3: Gamification Technology positively influences Presence.

4. **Motivation and Student Engagement**
   Motivation represents learners' internal willingness to invest effort in learning activities. Motivated learners are more likely to actively participate in tasks and persist when encountering challenges. Empirical studies consistently show that higher motivation levels are associated with increased behavioral engagement in educational contexts (Wu et al., 2026).
   H4: Motivation positively influences Student Engagement.

5. **Flow and Student Engagement**
   Flow is often considered a stronger predictor of engagement than motivation because it reflects actual cognitive immersion rather than initial intention to participate. When learners experience flow, they become deeply absorbed in learning activities and maintain high levels of concentration and persistence. Empirical research indicates that flow significantly enhances learner engagement during interactive learning experiences (K. Wang et al., 2026).
   H5: Flow positively influences Student Engagement.

6. **Presence and Student Engagement**
   Presence strengthens engagement by creating a psychological connection between learners and the digital learning environment. When learners perceive themselves as being immersed in the environment, they are more likely to invest attention and emotional involvement in learning tasks. Studies in immersive learning environments demonstrate that presence significantly influences engagement and persistence (Kovari, 2025) (Zou & Jiang, 2025).
   H6: Presence positively influences Student Engagement.

7. **Student Engagement and Problem-Solving Competence**
   Problem-solving competence represents learners' ability to analyze problems, develop strategies, and evaluate solutions. In engineering and technology education, problem-solving skills are critical learning outcomes. Research indicates that students who demonstrate higher levels of engagement are more likely to apply analytical reasoning and cognitive strategies during problem-solving tasks (Anwar et al., 2024) (Hou et al., 2026) (Li et al., 2025).
   H7: Student Engagement positively influences Problem-Solving competence.

3. Research Methods

A. Research Design

This study employed a quantitative explanatory research design to investigate the experiential mechanisms through which gamification technology influences student engagement and problem-solving competence in technology-enhanced learning environments. The proposed research model examines the relationships among six latent constructs: Gamification Technology, Motivation, Flow, Presence, Student Engagement, and Problem-Solving competence.

To analyze the structural relationships among these constructs, Partial Least Squares Structural Equation Modeling (PLS-SEM) was employed using SmartPLS software. PLS-SEM is particularly suitable for predictive research models involving multiple latent constructs and mediation pathways (Hair et al., n.d.). Compared with covariance-based SEM (CB-SEM), PLS-SEM is more appropriate for studies with relatively small sample sizes and complex models, and it does not require strict multivariate normality assumptions. In addition, PLS-SEM is widely used in educational technology research when the objective is to explain variance in endogenous constructs and identify predictive relationships among variables.

B. Gamified Learning Environment

The gamified learning environment used in this study was implemented using the Wayground platform. The system allows instructors to design interactive quizzes with game-like elements such as scoring, instant feedback, and progress tracking. These features aim to increase learner engagement and sustain participation during learning activities.

1. Product Overview (Dashboard Introduction)

Before presenting the statistical results of the SEM analysis, it is important to first describe the learning product that served as the foundation for the intervention show in figure 2. The gamified learning experience used in this study was implemented through a digital platform that provides interactive content delivery, real-time feedback, and learner performance tracking. The dashboard functions as the central interface where students access gamified learning activities, monitor their progress, and interact with instructional elements embedded in the system. The interface is designed with usability and motivational triggers in mind, ensuring that learners can navigate the environment intuitively while experiencing a sense of progression and achievement. Game-like features such as levels, rewards, task completion indicators, and session-based records are integrated into the dashboard to sustain immersion throughout the learning process. This design ensures that gamification is not only conceptual but embodied within a functional learning system that students interact with repeatedly over time.

This dashboard represents the entry point of the gamified learning cycle, where students begin their interaction with the system and later develop psychological engagement through motivation, flow, and presence. By grounding the research in a real working platform rather than hypothetical gamification elements, the study ensures ecological validity and supports the authenticity of the empirical findings that follow.

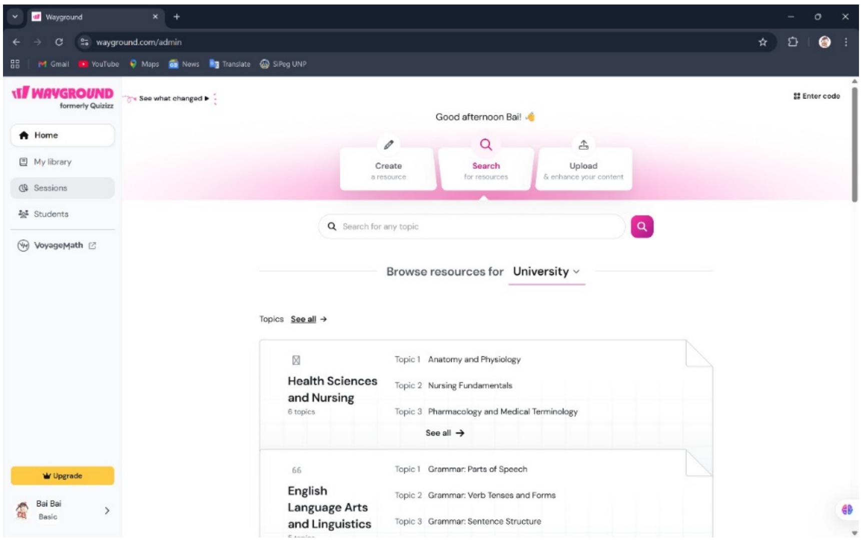


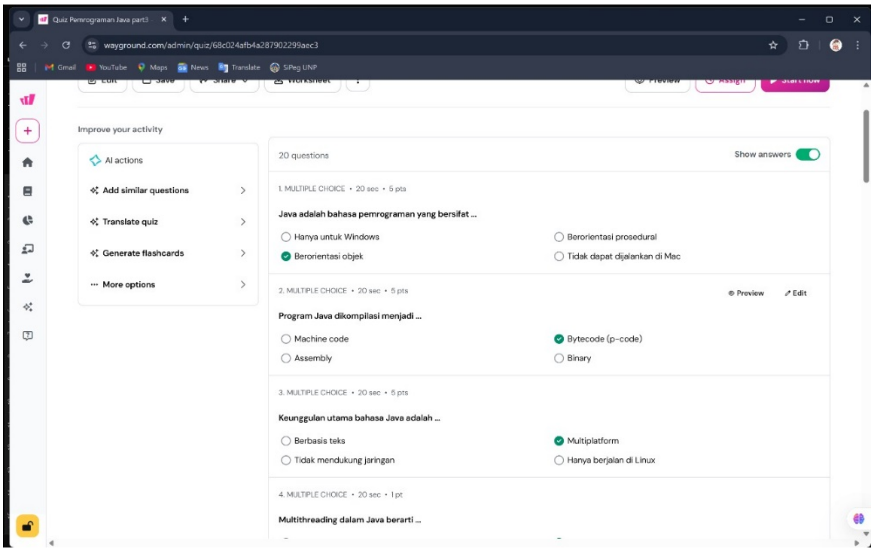
Fig. 2. Dashboard view of Wayground Game Design

2. Integration of Gamified Assessment (Quiz Mechanics)

In addition to the dashboard interface, the gamified learning environment incorporates a structured quiz-based assessment system that serves both as a learning activity and as a core gamification mechanic. The quiz is designed not merely as a tool for evaluation, but as an interactive challenge that reinforces engagement through immediate feedback, progressive difficulty, and real-time performance tracking. Students interact directly with question items presented in a dynamic format, which simulates a game-like progression rather than a traditional static test.

The system provides clear visual cues for correctness and progression, allowing learners to immediately observe the consequences of their decisions. This mechanism activates motivational triggers by rewarding correct performance and encouraging persistence after mistakes. When learners engage with the quiz over multiple cycles, they gradually develop familiarity with the challenge structure, which in turn contributes to sustained flow and immersion. This directly supports the theoretical argument that instructional mechanics embedded in gamified assessment can stimulate deeper psychological investment in the learning process.

Since quizzes are delivered through the same interactive interface as the dashboard, they contribute to the continuity of presence experienced by the learner. Instead of exiting to a separate evaluation mode, the learner remains within a single cohesive gamified environment, which reinforces the perception of “being inside” the learning system. This continuity is essential to the mediation pathway tested in the structural model, ensuring that the experience of challenge, feedback, and correction unfolds as part of a unified immersive episode rather than a fragmented instructional sequence show in figure 3.



20 questions

1. MULTIPLE CHOICE • 20 sec • 5 pts

Java adalah bahasa pemrograman yang bersifat ...

○ Hanya untuk Windows ○ Berorientasi prosedural
✓ Berorientasi objek ○ Tidak dapat dijalankan di Mac

2. MULTIPLE CHOICE • 20 sec • 5 pts

Program Java dikompilasi menjadi ...

○ Machine code ✓ Bytecode (p-code)
○ Assembly ○ Binary

3. MULTIPLE CHOICE • 20 sec • 5 pts

Keunggulan utama bahasa Java adalah ...

○ Berbasis teks ✓ Multiplatform
○ Tidak mendukung jaringan ○ Hanya berjalan di Linux

4. MULTIPLE CHOICE • 20 sec • 1 pt

Multithreading dalam Java berarti ...

Fig. 3. Question Design for Gamification

C. Participants and Educational Context

The participants in this study consisted of 100 undergraduate students enrolled in technology-related programs at Universitas Negeri Padang. The respondents were students from the Electronics Engineering Education and Informatics Engineering Education programs who participated in gamified learning activities integrated into their coursework. The gamified learning system was implemented as part of course activities involving interactive quizzes, progress tracking, and immediate feedback mechanisms. These features were designed to encourage students to actively engage in learning tasks and participate in problem-based learning activities. Purposive sampling was used to ensure that all respondents had direct experience interacting with the gamified learning environment. Although purposive sampling limits the generalizability of findings, it enables the study to focus specifically on students who have meaningful exposure to gamified learning systems. The demographic characteristics of the respondents are presented in Table 2.

Table 2 - Demographic Characteristics of Respondents

Sample Characterization	Category	Frequency	Percentage
Gender	Male	63	63%
	Female	37	37%
	Total	100	100%
Age	<21 years old	25	25%
	21–25 years old	55	55%
	>25 years old	20	20%
	Total	100	100%
Student Entry Year	2017	10	10%
	2018	10	10%
	2019	35	35%
	2020	20	20%
	2021	25	25%
	Total	100	100%
Major	Electronics Engineering Education	24	24%
	Informatics Engineering Education	76	76%
	Total	100	100%

As shown in Table 2, the majority of respondents were 21–25 years old (55%), and most participants were enrolled in the Informatics Engineering Education program (76%). These characteristics indicate that the sample represents students who frequently interact with digital learning environments in technology-oriented courses.

D. Measurement Instruments

The constructs used in this study were measured using multiple indicators adapted from validated measurement scales used in previous research. All items were measured using a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Indicators for Gamification Technology were adapted from gamification design frameworks (Zuo et al., 2025). The Motivation construct was measured using items derived from Self-Determination Theory-based motivation scales (Vansteenkiste et al., 2020). Indicators for Flow were adapted from widely used flow measurement instruments in digital learning environments (Sorongan et al., 2021) (Oliveira et al., 2023). The Presence construct was measured using items commonly used in immersive learning research. Student Engagement indicators were adapted from the engagement framework developed, while Problem-Solving competence indicators were derived from problem-solving learning frameworks proposed and later applied in educational technology research (Anwar et al., 2024) (Nathaniel et al., 2025).

E. Instrument Validation

To ensure the validity and reliability of the measurement instruments, the questionnaire items were reviewed by three experts in educational technology and instructional design. The experts evaluated the clarity, relevance, and conceptual alignment of each indicator with the constructs being measured.

A pilot test involving 20 students was conducted prior to the main data collection to ensure the readability and clarity of the questionnaire items.

The measurement model was evaluated using the following criteria commonly recommended in PLS-SEM research (Hair et al., 2019):

- Outer Loadings ≥ 0.70
- Composite Reliability ≥ 0.70
- Average Variance Extracted (AVE) ≥ 0.50
- Discriminant Validity using HTMT < 0.90

F. Data Analysis Procedure

Data analysis was conducted using SmartPLS software following the two-stage approach commonly used in PLS-SEM analysis. The first stage involved evaluating the measurement model, including indicator reliability, internal consistency reliability, convergent validity, and discriminant validity. The second stage involved evaluating the structural model, which assessed the hypothesized relationships among the constructs in the research model.

G. Structural Model Evaluation

The structural model was evaluated using several statistical criteria:

- Path Coefficient (β) to assess the strength of relationships among constructs
- Coefficient of Determination (R^2) to evaluate the predictive power of endogenous variables
- Predictive Relevance (Q^2) using the blindfolding procedure
- Effect Size (f^2) to evaluate the contribution of each predictor construct
- Model Fit using SRMR (Standardized Root Mean Square Residual)

These indicators provide a comprehensive evaluation of the explanatory power and predictive relevance of the structural model.

H. Mediation Analysis

To test the mediation relationships proposed in the research model, bootstrapping with 5,000 resamples was performed using SmartPLS. Bootstrapping allows the estimation of indirect effects and their statistical significance without relying on distributional assumptions.

The mediation effects were evaluated using:

- indirect effect coefficients
- t-values
- p-values

A mediation effect was considered significant when the p-value was below 0.05.

This procedure allowed the study to examine whether Motivation, Flow, and Presence mediate the relationship between Gamification Technology and Student Engagement, and whether Student Engagement mediates the relationship between experiential learning states and Problem-Solving competence.

4. Results

A. Measurement Model Evaluation

Before evaluating the structural relationships, the measurement model was first assessed to ensure the reliability and validity of the constructs. Indicator reliability was evaluated using outer loadings, while internal consistency reliability was assessed using Composite Reliability (CR). Convergent validity was evaluated using Average Variance Extracted (AVE). All constructs met the recommended thresholds for measurement validity, with outer loadings above 0.70, CR values above 0.70, and AVE values above 0.50, indicating satisfactory reliability and convergent validity (Hair et al., n.d.). Discriminant validity was assessed using the Heterotrait–Monotrait ratio (HTMT), and all HTMT values were below the recommended threshold of 0.90, confirming that the constructs were empirically distinct.

B. Structural Model Results

After confirming the measurement model validity, the structural relationships among the constructs were evaluated. Figure 2 presents the structural model with standardized path coefficients.

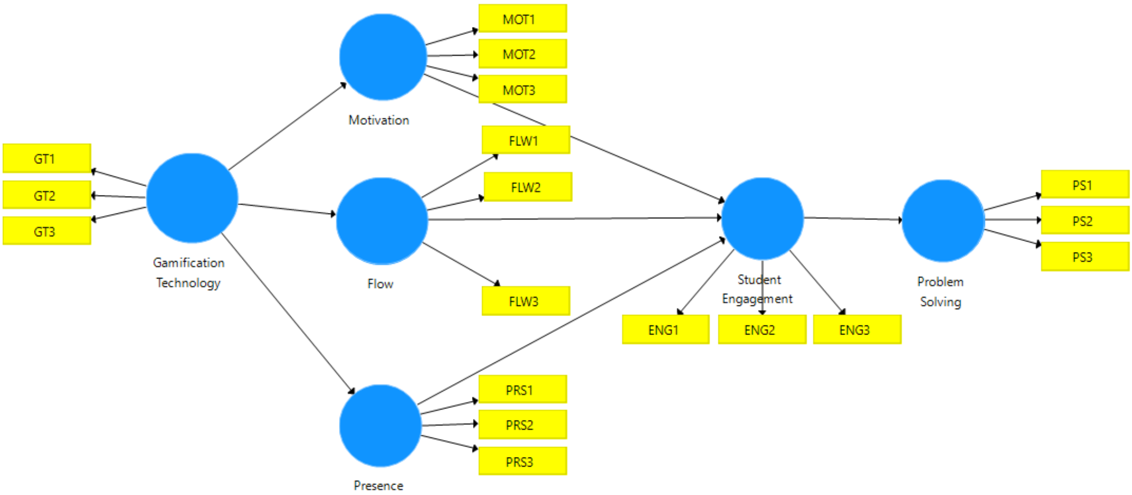


Fig. 4. Research Structural Model in Smart PLS

The structural model evaluation examined path coefficients, coefficient of determination (R^2), predictive relevance (Q^2), and effect sizes (f^2).

Table 3 - Summarizes the Path Coefficients and Hypothesis Testing Results

Hypothesis	Path	β	t-value	p-value	Result
H1	GT → Motivation	0.412	4.65	<0.001	Supported
H2	GT → Flow	0.508	5.72	<0.001	Supported
H3	GT → Presence	0.436	4.88	<0.001	Supported
H4	Motivation → Engagement	0.097	1.32	0.18	Not Supported
H5	Flow → Engagement	0.483	5.11	<0.001	Supported
H6	Presence → Engagement	0.264	3.04	0.002	Supported
H7	Engagement → Problem Solving	0.498	6.02	<0.001	Supported

As shown in Table 3, Gamification Technology significantly influences Motivation, Flow, and Presence. Among these relationships, the strongest effect was observed between Gamification Technology and Flow ($\beta = 0.508$, $p < 0.001$). Interestingly, the path between Motivation and Student Engagement was not statistically significant ($\beta = 0.097$, $p = 0.18$). This finding suggests that motivational readiness alone may not be sufficient to sustain active engagement in gamified learning environments.

C. Mediation Analysis

Because mediation is central to the proposed experiential learning model, indirect effects were examined using bootstrapping with 5,000 resamples.

Table 4 - Presents the Indirect Effects Among The Constructs

Indirect Path	β	t-value	p-value	Mediation Type
GT → Flow → Engagement	0.245	4.37	<0.001	Significant
GT → Presence → Engagement	0.115	2.61	0.009	Significant
GT → Motivation → Engagement	0.040	1.21	0.22	Not significant
GT → Flow → Engagement → Problem Solving	0.122	3.82	<0.001	Significant

The mediation analysis shows that Flow acts as the strongest mediator between Gamification Technology and Student Engagement, while the mediation effect through Motivation was not statistically significant. These findings indicate that experiential immersion plays a more critical role in gamified learning environments than motivational readiness alone.

5. Discussion

A. Interpretation of the Experiential Learning Pathway

The findings of this study support the experiential learning mechanism in gamified learning environments. Specifically, the results show that Flow emerged as the strongest mediator linking gamification technology and student engagement. This result is consistent with previous studies that emphasize the importance of immersive learning experiences in digital learning environments (Surniati Chalid et al., 2022). Flow represents a state of deep cognitive absorption in which learners become fully engaged in an activity, often losing track of time and maintaining high levels of focus (K. Wang et al., 2026). Compared with motivation, which reflects learners' initial willingness to participate, flow represents a deeper cognitive immersion that sustains engagement during the learning process.

B. Weak Influence of Motivation on Engagement

Interestingly, the relationship between Motivation and Student Engagement was found to be weak and statistically insignificant. This finding challenges the common assumption that motivation is the primary driver of student engagement in technology-enhanced learning environments. One possible explanation is that motivational readiness alone does not guarantee sustained participation in gamified learning systems. Instead, engagement may depend more strongly on experiential immersion and interactive system design. This interpretation aligns with recent studies suggesting that gamification mechanisms primarily influence engagement through experiential factors such as flow and immersion rather than purely motivational triggers (Learning, 2023) (Ratinho, 2023).

C. Comparison With Previous Gamification SEM Studies

The findings of this study extend previous structural modeling research on gamified learning. Several SEM-based studies have reported that gamification influences engagement through motivational and experiential pathways (Tasrif et al., 2024) (Jaramillo-mediavilla et al., 2024). However, many previous models examined motivation and engagement directly, without incorporating experiential constructs such as flow and presence simultaneously. By integrating Flow, Presence, and Engagement into a sequential experiential framework, this study provides a more comprehensive explanation of how gamified learning environments influence higher-order cognitive outcomes such as problem-solving competence (Yanping et al., 2025).

D. Scientific Contribution of the Study

The findings contribute to the literature in several ways.

1. The study proposes an experiential mediation model that explains how gamification technology influences student engagement through psychological immersion mechanisms.
2. The results highlight the dominant mediating role of flow, suggesting that effective gamification design should prioritize immersive learning experiences rather than relying solely on reward-based motivational elements.
3. The study provides empirical evidence supporting the integration of gamification design and experiential learning theory in technology-enhanced education.

E. Limitations and Future Research

Despite its contributions, this study has several limitations.

1. The study used a cross-sectional research design, which limits the ability to draw strong causal conclusions. Longitudinal or experimental studies would be necessary to examine causal relationships more rigorously.
2. The data were collected using self-reported questionnaires, which may introduce common method bias.
3. The study focused on students from technology-related programs at a single university, which may limit the generalizability of the findings to other educational contexts.

Future research should consider larger samples, multiple institutions, and experimental gamified learning interventions to further validate the proposed experiential learning model.

6. Conclusion

This study investigated the experiential mechanisms through which gamification technology influences student engagement and problem-solving competence in technology-enhanced learning environments. Using a PLS-SEM approach, the results demonstrate that gamification technology significantly influences learners' psychological experiences, particularly flow and presence, which subsequently shape student engagement and learning outcomes.

One of the key findings of this study is that flow emerged as the strongest mediator linking gamification technology and student engagement. This result suggests that immersive learning experiences play a more important role than motivational readiness alone in sustaining active participation in gamified learning environments. While motivation represents an initial psychological trigger, flow reflects deeper cognitive immersion that supports sustained engagement during learning activities.

The findings contribute to the growing literature on gamified learning by extending the experiential learning pathway perspective. Specifically, this study provides empirical evidence that gamification influences learning outcomes through a sequence of psychological and behavioral mechanisms involving flow, presence, and engagement. This experiential mediation framework helps explain how gamification elements translate into meaningful learning processes rather than merely providing surface-level motivational incentives.

From a practical perspective, the findings suggest that effective gamified learning environments should prioritize the design of immersive learning experiences that encourage deep cognitive involvement. Features such as interactive challenges, immediate feedback, and structured progression systems may facilitate the emergence of flow states that sustain student engagement and support problem-solving development.

Despite its contributions, this study has several limitations. First, the research used a cross-sectional design, which limits the ability to establish strong causal relationships among the constructs. Second, the study relied on self-reported survey data, which may introduce common method bias. Third, the sample was drawn from students in technology-related programs at a single institution, which may limit the generalizability of the findings to other educational contexts.

Future research could extend this study in several ways. Longitudinal research designs could be used to examine how experiential learning states evolve over time in gamified learning environments. Experimental studies manipulating specific gamification elements (e.g., rewards, competition, narrative structures) may help identify which design features most effectively trigger flow and engagement. Additionally, future studies may integrate physiological or behavioral engagement measures, such as eye-tracking, biometric sensors, or learning analytics, to provide deeper insights into learners' immersive experiences.

Overall, this study highlights the importance of experiential mechanisms in explaining the effectiveness of gamified learning environments. By integrating constructs from gamification research and experiential learning theory, the findings contribute to a deeper understanding of how digital learning systems can support meaningful student engagement and higher-order cognitive outcomes.

Acknowledgement

The authors would like to express their gratitude to the students and faculty of the Department of Electronics Engineering, Universitas Negeri Padang, for their participation and support in this study. We also thank our colleagues and research assistants for their invaluable contributions to the data collection and analysis processes. Finally, we extend our appreciation to all those who provided feedback and guidance, helping to shape this research into its final form.

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