

Game-Based Learning Experience and Occupational Health and Safety Learning Achievement: The Mediating Role of Learning Engagement in Vocational Training

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Abstract

Occupational health and safety is a mandatory component of public vocational training; however, lecture-based instruction may not sufficiently engage adult learners. This study examined the effect of the game-based learning experience on learning achievement, with learning engagement as a mediating variable, among occupational health and safety trainees at the South Jakarta Regional Job Training Center, Indonesia. A quantitative explanatory survey was conducted with all 174 participants enrolled in the 2026 Batch 1 regular and Mobile Training Unit classes using saturated sampling. All participants completed a game-based learning session on the Wayground platform, formerly known as Quizizz. Data were collected using a five-point Likert-scale questionnaire adapted from established instruments and analyzed using partial least squares structural equation modeling (PLS-SEM) with SmartPLS 4. The game-based learning experience had a positive and significant effect on learning engagement ($\beta = 0.854$, $p < 0.001$) and learning achievement ($\beta = 0.592$, $p < 0.001$), while learning engagement had a positive and significant effect on learning achievement ($\beta = 0.343$, $p = 0.016$). Learning engagement partially mediated the effect of the game-based learning experience on learning achievement (indirect effect = 0.293, $p = 0.017$). The model explained 72.9% of the variance in learning engagement and 81.6% of the variance in learning achievement. Approximately one-fifth of participants reported technical barriers, primarily unstable internet connections, system lag, device limitations, and game time limits perceived as too short. The findings suggest that game-based learning activities can enhance learner engagement and perceived learning achievement in occupational health and safety training for adult vocational learners, provided that adequate technical readiness is ensured.



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INTRODUCTION

Occupational health and safety (OHS; known in Indonesia as Keselamatan dan Kesehatan Kerja or K3) is a systematic effort to protect workers, the work environment, and organizational assets from hazards that may cause occupational accidents and diseases (Lubis et al., 2024). OHS encompasses not only regulatory compliance but also the creation of safe, healthy, and productive working conditions. In practice, it includes hazard identification, risk control, the

use of personal protective equipment, and emergency preparedness and response in the workplace (Setiawan et al., 2023).

Occupational accidents in Indonesia remain a serious concern. By the end of 2024, more than 356,000 work-related accident cases had been recorded across sectors, including manufacturing and construction (Kompas, 2025). This situation underscores the importance of OHS knowledge, which has consistently been associated in the literature with a lower incidence of occupational accidents (Lubis et al., 2024).

In an increasingly dynamic and competitive labor market, vocational skills play a central role in workforce readiness (Kovalchuk et al., 2022). Individuals with strong vocational competencies are expected not only to perform technical tasks but also to solve problems, adapt to change, and work safely and accurately (Li & Pilz, 2023). Through practice-based training, simulations, and hands-on experience, vocational learners can develop an understanding of actual workplace conditions and acquire competencies aligned with labor market needs (McGrath & Yamada, 2023).

The South Jakarta Regional Job Training Center (Pusat Pelatihan Kerja Daerah Jakarta Selatan, hereafter PPKD South Jakarta) is a technical implementation unit that provides vocational skills training to prepare a competent workforce. Its programs are designed to equip participants with technical competencies, professional attitudes, and readiness for actual workplace environments, thereby helping to reduce the gap between job seekers' competencies and labor market demands. OHS is a compulsory foundational component of all training programs.

Because PPKD South Jakarta sets a minimum entry age of 17 years and no upper age limit, its trainees represent a heterogeneous group of adult and near-adult learners with diverse life experiences and predominantly practical, work-oriented learning needs. According to Knowles et al. (2015), adult learning is more effective when it is participatory, relevant to real-world needs, and grounded in experience. Adult learners tend to benefit from active engagement, discussion, problem solving, and opportunities to connect new material with their work or daily experiences rather than from purely passive instruction. Consequently, rigid, instructor-centered approaches may be less effective for this learner population.

In practice, OHS training at PPKD South Jakarta has largely relied on lecture-based instruction delivered during an eight-hour session, which may reduce sustained attention and increase learner fatigue or boredom. At the same time, adult learners may experience excessive cognitive load when technology-supported instruction is poorly designed, potentially undermining motivation and engagement (Baah et al., 2024; Evans et al., 2024). Instructional innovations for this group therefore need to be engaging while remaining accessible and easy to use.

Pre-test and post-test records from OHS classes at PPKD South Jakarta between 2024 and 2026 showed substantial variation in learning gains. In 2024, the average score increased by only 2.0 points, from 61.5 to 63.5, whereas in 2025 the increase was considerably larger at 18.0 points, from 60.5 to 78.5. In 2026, the average score increased by 12.9 points, from 42.4 to 55.3; however, the post-test average remained well below that recorded in 2025, while the pre-test average was the lowest across the three years, indicating a weaker baseline level of OHS knowledge among incoming trainees. These fluctuations suggest that OHS learning outcomes

have not been consistent and indicate the need for instructional approaches that more actively engage trainees.

From the perspective of constructivist learning theory, learners actively construct knowledge through experience, interaction, and direct participation in learning activities (Almulla, 2023). Game-based learning is consistent with this perspective because it engages learners through challenges, simulations, and interactive experiences that may resemble real-world situations (Esteban, 2024). Game-based learning incorporates game elements, mechanics, and structures, such as rules, goals, progressive challenges, and immediate feedback, to support educational objectives (Videnovik et al., 2023). Meta-analytic evidence comparing game-based learning and gamification has also reported generally positive effects on learning achievement and motivation (Zhang & Yu, 2022).

Empirical studies have supported the relationships among game-based learning, engagement, and achievement. Game-based quizzes and simulation games have been shown to increase learner engagement and motivation compared with conventional learning activities (Nadeem et al., 2023; Zubair et al., 2024), while gamified learning has been associated with higher engagement and academic performance among training participants and university students (Hamadneh et al., 2025; Neerupa & William, 2024). Game-based learning media have also been reported to improve learning achievement in school settings (Irhad & Ismail, 2023), and weekly game-based quiz performance on Quizizz has been found to predict students' examination scores (Pum, 2025). Other studies have identified engagement as a mechanism through which gamification influences learning effectiveness and satisfaction (Nguyen-Viet & Nguyen-Viet, 2023; Nusairat et al., 2024). However, the evidence is not entirely consistent. Wardoyo et al. (2021) found that game-based learning in distance education did not mediate the academic achievement of Indonesian high school students, suggesting that its effectiveness may depend on the implementation context.

Despite this evidence, most previous studies have focused on school or university students in formal educational settings, while relatively few have examined game-based learning among adult trainees in public vocational training centers, particularly in the context of OHS education. Studies simultaneously examining the direct effect of game-based learning experience on learning achievement and the mediating role of learning engagement in this setting also remain limited. To address this gap, the present study examined the effect of game-based learning experience delivered through the Wayground platform, formerly Quizizz (THE Journal, 2025), on the learning achievement of OHS trainees at PPKD South Jakarta, with learning engagement as a mediating variable. The following hypotheses were tested: (H1) game-based learning experience has a positive effect on learning achievement; (H2) game-based learning experience has a positive effect on learning engagement; (H3) learning engagement has a positive effect on learning achievement; and (H4) learning engagement mediates the effect of game-based learning experience on learning achievement.

METHOD

Research Design

This study employed a quantitative explanatory survey design to test the hypothesized relationships among game-based learning experience (GBL), learning engagement (LE), and learning achievement (LA) (Sugiyono, 2022). Data were collected cross-sectionally through a questionnaire administered after participants completed a game-based occupational health and safety (OHS) learning session. The hypothesized relationships were analyzed using partial least squares structural equation modeling (PLS-SEM), with LE examined as a mediating variable between GBL and LA.

Place, Time, Subject, and Research Procedure

The study was conducted at PPKD South Jakarta during the April–May 2026 training period. The participants were trainees in the 2026 Batch-1 regular classes and vocational Mobile Training Unit (MTU) classes who received the general OHS module. The researcher did not act as an instructor and was not involved in delivering the material; the researcher's role was limited to observation and data collection. The study was conducted with permission from the management of PPKD South Jakarta. Participation was voluntary: the opening statement of the questionnaire explained the purpose of the study, asked for participants' willingness to take part, and assured them that their responses would be kept confidential and used only for research purposes.

Population and Sample

The population comprised all 174 trainees in the 2026 Batch-1 regular and MTU classes. A saturated sampling (census) technique was used, in which all members of the population were included as respondents. All 174 questionnaires were returned complete and were analyzed.

Data Collection Techniques and Research Instruments

Data were collected using a questionnaire with a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). The instruments were adapted from previous studies, as summarized in Table 1.

Table 1. Summary of Research Instruments

Variable	Dimensions	Number of Items	Adaptation Source
Game-Based Learning Experience (Exogenous)	Attention, Relevance, Confidence, Satisfaction	17 (13 retained)	Jääskä et al. (2022)
Learning Engagement (Endogenous/Mediation)	Affective, Behavioral, Cognitive	6	Baah et al. (2024)
Learning Achievement (Endogenous)	Clarity of learning guidance, concept comprehension, speed of comprehension, application of OHS concepts	4	Youssef et al. (2024)

Source: Jääskä et al. (2022), Baah et al. (2024), and Youssef et al. (2024), processed by the authors (2026).

Content validity was assessed through expert judgment by three experts in learning technology, educational evaluation, and OHS. The experts judged most items to be appropriate and recommended revisions to several items, mainly to adapt the wording to the OHS context and to reduce overlap between similar items. The items were revised accordingly, and three

items were added to the GBL scale (decision-making in risky situations, satisfaction with the learning experience, and usefulness of in-game feedback), resulting in a final questionnaire of 17 GBL items, 6 LE items, and 4 LA items. Two GBL items (GBL4 and GBL8) were negatively worded. The questionnaire also included a closed question on whether participants experienced obstacles during the game-based session and an open question asking them to describe those obstacles.

Game-Based Learning Intervention

OHS training at PPKD South Jakarta has conventionally been delivered through lectures, discussions, and written tests in a one-day session. In this study, a game-based session on the Wayground platform was integrated into the regular OHS training, while the material, duration, and instructors of the face-to-face component remained the same as in the regular training. Participants accessed the game through a link shared via WhatsApp on 6, 7, and 17 April and 4 May 2026. Each session consisted of 30 questions to be completed within 15 minutes and covered OHS terminology, the objectives of OHS training, the procedure for using a portable fire extinguisher, and a comprehension check. The questions were presented visually with scenario-based answer options, and the platform provided real-time scoring, instant feedback, a leaderboard, and an automatic score report recording each participant's score, completion time, and accuracy. After completing the game, participants filled out the online questionnaire independently (6 April–5 May 2026). Because the study did not include a comparison group that received conventional training only, differences between the two delivery approaches were not tested.

Data Analysis Techniques

Data were analyzed using PLS-SEM in SmartPLS 4 (Ghozali & Latan, 2020; Manley et al., 2021). The measurement model was evaluated through indicator loadings (≥ 0.70), average variance extracted ($AVE \geq 0.50$), discriminant validity (cross-loadings), and internal consistency reliability (Cronbach's alpha and composite reliability ≥ 0.70). The structural model was evaluated using the coefficient of determination (R^2), effect size (f^2 ; 0.02, 0.15, and 0.35 indicating small, medium, and large effects, respectively), predictive relevance ($Q^2 > 0$), and model fit ($SRMR \leq 0.08$; $NFI > 0.80$). Direct and indirect effects were tested through bootstrapping with a two-tailed test; a path was considered significant when $t \geq 1.96$ and $p < 0.05$.

RESULTS AND DISCUSSION

Respondent Characteristics

The characteristics of the 174 study respondents are presented in Table 2 below.

Table 2. Characteristics of Respondents

Characteristics	Category	n	%
Gender	Female	89	51.15
	Male	85	48.85
Age	17–25 years	113	64.94
	26–35 years	39	22.41
	> 36 years	22	12.64
Vocational program (largest groups)	Culinary arts	21	12.07

Obstacles during the game-based session	Graphic Design / Data Management Staff	20 / 20	11.49 / 11.49
	Hospitality	19	10.92
	No obstacles	137	78.74
	Experienced obstacles (e.g., internet connection, game duration, unfamiliarity with the game)	37	21.26

Source: Questionnaire, Data Processed 2026

Female participants slightly outnumbered male participants (51.15% vs. 48.85%), and most participants were aged 17–25 years (64.94%). Participants came from a wide range of vocational programs, including culinary arts, graphic design, data management staff, hospitality, computer engineering, barista, and MTU programs. Most participants (78.74%) reported no obstacles in following the game-based session. The remaining 21.26% mainly reported technical obstacles, such as unstable internet connections, lagging, low device batteries, or browsers that did not fully support the game, as well as game time limits perceived as too short and unfamiliarity with digital game mechanics. A few participants also reported that the game drew their attention away from the OHS content, that they felt nervous, or that accessibility features (e.g., support for participants with hearing impairments) were needed.

Description of Research Variables

Mean scores were interpreted using the following intervals: 1.00–1.79 (strongly disagree), 1.80–2.59 (disagree), 2.60–3.39 (neutral), 3.40–4.19 (agree), and 4.20–5.00 (strongly agree). For GBL, the positively worded items had means between 3.84 and 4.34 (agree to strongly agree). The highest mean was for “I found learning through games fun and interesting” (Attention dimension; $M = 4.34$), whereas the two negatively worded items, “Learning the rules and mechanics of the game felt confusing and frustrating” ($M = 2.91$) and “The game’s narrative and environment did not match real workplace conditions” ($M = 3.02$), fell into the neutral category. LE item means ranged from 4.02 to 4.13 (agree), with the highest for “When facing difficult tasks, I keep trying until I succeed because I feel satisfied after succeeding” (Behavioral dimension; $M = 4.13$). LA item means ranged from 4.03 to 4.05 (agree), with the highest for “I obtained clear and structured learning guidance through game-based learning activities on general OHS material” and “Game-based learning helped me apply general OHS concepts in real work situations” ($M = 4.05$).

Measurement Model Evaluation

In the first iteration, four GBL indicators had loadings below 0.70: GBL1 (0.659), GBL4 (−0.085), GBL8 (−0.156), and GBL15 (0.699). These indicators were removed, and the model was re-estimated. In the second iteration, all retained indicators had loadings above 0.70 (GBL: 0.776–0.881; LE: 0.832–0.909; LA: 0.907–0.939), and all AVE values exceeded 0.50 (Table 3), indicating adequate convergent validity.

Table 3. Average Variance Extracted (Second Iteration)

Variable	AVE	Remarks
Game-Based Learning Experience	0.711	Valid
Learning Engagement	0.764	Valid
Learning Achievement	0.853	Valid

Source: SmartPLS 4.0 Output, Data Processed 2026

The cross-loadings showed that each indicator loaded more strongly on its own construct than on any other construct, indicating discriminant validity at the indicator level. The reliability results are presented in Table 4.

Table 4. Reliability Test Results

Variable	Cronbach's Alpha	Composite Reliability	Remarks
Game-Based Learning Experience	0.943	0.943	Reliable
Learning Engagement	0.938	0.939	Reliable
Learning Achievement	0.966	0.967	Reliable

Source: SmartPLS 4.0 Output, Data Processed 2026

Structural Model Evaluation

The structural model results are summarized in Table 5. GBL explained 72.9% of the variance in LE, and GBL and LE together explained 81.6% of the variance in LA; both values fall into the substantial category ($R^2 > 0.67$). The effects of GBL on LE ($f^2 = 2.690$) and on LA ($f^2 = 0.516$) were large, whereas the effect of LE on LA was medium ($f^2 = 0.174$). Q^2 values above zero indicated predictive relevance for both endogenous constructs, and the SRMR (0.048) and NFI (0.849) values met the recommended thresholds.

Table 5. Summary of Structural Model Evaluation

Criteria	Results	Remarks
R-Square - Learning Engagement	0.729 (Adjusted 0.727)	72.9% of the variance in LE explained by GBL
R-Square - Learning Achievement	0.816 (Adjusted 0.814)	81.6% of the variance in LA explained by GBL and LE
f-Square – GBL → LE	2.690	Large
f-Square – GBL → LA	0.516	Large
f-Square – LE → LA	0.174	Medium
Q^2 - Learning Engagement	0.715	Predictive relevance ($Q^2 > 0$)
Q^2 - Learning Achievement	0.777	Predictive relevance ($Q^2 > 0$)
Model Fit - SRMR	0.048	Good fit (≤ 0.08)
Model Fit - NFI	0.849	Good fit (> 0.80)

Source: SmartPLS 4.0 Output, Data Processed 2026

Hypothesis Test Results

Table 6 presents the bootstrapping results for the direct and indirect effects.

Table 6. Results of the Significance Test of Direct and Indirect Influence

Pathway	Coefficient (O)	T-Statistic	P-Values	Remarks
H1: GBL → LA (direct)	0.592	4.371	< 0.001	Supported
H2: GBL → LE (direct)	0.854	26.137	< 0.001	Supported
H3: LE → LA (direct)	0.343	2.410	0.016	Supported
H4: GBL → LE → LA (indirect)	0.293	2.391	0.017	Supported

Source: SmartPLS 4.0 Output, Data Processed 2026

All four hypotheses were supported. Because both the direct effect of GBL on LA ($\beta = 0.592$, $p < 0.001$) and the indirect effect through LE ($\beta = 0.293$, $p = 0.017$) were positive and significant, LE acted as a complementary partial mediator. The indirect effect accounted for approximately 33% of the total effect of GBL on LA (0.293 of 0.885).

Discussion

The strongest relationship in the model was between GBL and LE ($\beta = 0.854$; $f^2 = 2.690$), indicating that participants who evaluated the game-based session more positively also reported higher affective, behavioral, and cognitive engagement. This finding is consistent with studies showing that game-based quizzes and simulation games increase engagement and motivation (Nadeem et al., 2023; Zubair et al., 2024) and that gamified learning is associated with higher engagement among training participants and university students (Hamadneh et al., 2025; Neerupa & William, 2024). From a constructivist perspective, challenges, immediate feedback, and competition place learners in an active rather than passive role (Almulla, 2023), which is particularly relevant for adult learners who prefer participatory and problem-centered learning (Knowles et al., 2015). The highest-rated engagement item, persistence in completing difficult tasks because of the satisfaction of succeeding, is also in line with self-determination theory, which holds that experiences of competence support intrinsic motivation (Guay, 2022).

GBL also had a direct positive effect on LA ($\beta = 0.592$; $f^2 = 0.516$). Participants who had a better game-based learning experience reported better understanding of the OHS material, faster comprehension, and a greater ability to apply OHS concepts in work situations. The highest-rated achievement items concerned clear, structured learning guidance and the application of OHS concepts, suggesting that the structured question format and immediate feedback functioned as scaffolding that helped participants organize OHS knowledge. This result is in line with studies reporting positive effects of game-based learning media on learning achievement (Irhad & Ismail, 2023) and of game-based quiz performance on examination scores (Pum, 2025). In contrast, Wardoyo et al. (2021) found that game-based learning in a distance-learning context did not act as a mediator of students' achievement, suggesting that its benefits depend on how it is embedded in instruction. In this study, the game session was integrated into face-to-face OHS training with the same material and instructors, which may have supported its contribution.

LE had a positive, medium-sized effect on LA ($\beta = 0.343$; $f^2 = 0.174$). Participants who considered the material important, looked forward to the activities, persisted with difficult tasks, and related new material to their prior knowledge reported higher learning achievement. This finding supports the constructivist view that knowledge is built through active involvement and is consistent with studies identifying engagement as a pathway to learning effectiveness in gamified settings (Nguyen-Viet & Nguyen-Viet, 2023). The medium effect size also indicates that learning achievement is shaped by factors beyond engagement, such as prior knowledge, delivery methods, and the technical conditions of implementation.

The mediation analysis showed that LE partially mediated the effect of GBL on LA (indirect effect = 0.293; $p = 0.017$). Thus, GBL appears to be associated with achievement both directly and through increased engagement: when participants find the activity interesting, enjoy the process, and participate actively, they are more likely to report that they understand and can apply OHS concepts. This pattern is consistent with previous studies in which engagement mediated the effects of gamification on learning outcomes and satisfaction (Nguyen-Viet & Nguyen-Viet, 2023; Nusairat et al., 2024). The larger direct effect relative to the indirect effect suggests that design features of the game itself, such as structured content

and immediate feedback, contribute to perceived achievement beyond their effect on engagement.

The reported obstacles show that the benefits of game-based learning depend on implementation conditions. Unstable internet connections, lagging, device limitations, and time limits perceived as too short can disrupt participants' focus, and unfamiliarity with game mechanics can add extraneous cognitive load for adult learners (Evans et al., 2024). The neutral ratings of the negatively worded items on confusing game mechanics and on the realism of the game environment point to the same areas for improvement: simpler rules with a brief tutorial and OHS scenarios that more closely resemble real workplaces.

This study has several limitations. First, the cross-sectional, single-group design without a control group does not allow causal conclusions or a comparison between game-based and conventional OHS training (Sekaran & Bougie, 2016). Second, all constructs, including LA, were measured through self-reports collected with the same questionnaire, which may introduce social desirability and common method bias and inflate the relationships among constructs (Podsakoff et al., 2012); in particular, the LA items reflect participants' perceptions of what game-based learning helped them achieve rather than objective test scores. Third, the sample was limited to one training center and one cohort, which restricts generalizability to other training contexts. Finally, although the researcher acted only as an observer to minimize the Hawthorne effect (McCambridge et al., 2014), participants' awareness of being studied may still have influenced their responses.

CONCLUSION

This study concludes that game-based learning is an effective instructional approach for supporting learning engagement and perceived learning achievement among occupational health and safety (OHS) trainees at PPKD South Jakarta. The findings showed that the game-based learning experience had a positive and significant effect on learning achievement ($\beta = 0.592$, $p < 0.001$) and an even stronger effect on learning engagement ($\beta = 0.854$, $p < 0.001$). Learning engagement also had a positive and significant effect on learning achievement ($\beta = 0.343$, $p = 0.016$) and partially mediated the relationship between game-based learning experience and learning achievement, with an indirect effect of $\beta = 0.293$ ($p = 0.017$). The model explained 72.9% of the variance in learning engagement and 81.6% of the variance in learning achievement, indicating substantial explanatory power. These findings suggest that interactive, feedback-oriented, and participatory game-based activities can strengthen trainees' affective, behavioral, and cognitive engagement while supporting their understanding and application of OHS concepts. Therefore, integrating brief game-based quizzes, scenario-based challenges, and immediate feedback into vocational OHS training may provide a meaningful complement to conventional instructional methods.

Future research should strengthen the evidence by employing experimental or quasi-experimental designs with control or comparison groups to determine more clearly whether game-based learning produces better outcomes than conventional OHS instruction. Learning achievement should also be assessed using objective measures, such as pre-test and post-test scores, platform-based performance data, practical competency assessments, and longer-term knowledge-retention measures, rather than relying predominantly on participants' self-reported perceptions. Future studies should also involve multiple vocational training centers, occupational programs, age groups, and participant cohorts to improve the generalizability of

the findings. In addition, subsequent research could examine other mediating or moderating variables, such as learning motivation, digital literacy, prior knowledge, cognitive load, technological readiness, and accessibility conditions, particularly because some participants experienced unstable internet connections, device limitations, unfamiliar game mechanics, and restrictive time limits. Such research would provide a more comprehensive understanding of the conditions under which game-based learning can produce sustained improvements in vocational OHS education.

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AUTHOR CONTRIBUTION

RSJN: conceptualization, methodology, data collection, formal analysis, and writing – original draft. RP: supervision, validation of the research design and analysis, and writing – review and editing. Both authors have read and approved the final manuscript.

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The authors state that generative artificial intelligence (AI) was used in the preparation of this manuscript. The authors acknowledge the use of generative AI to help improve the language clarity and grammatical structure of the manuscript. This use complied with applicable ethical guidelines on the use and disclosure of generative AI in scientific research. Each author has made substantial intellectual contributions to this work. The entire content of the manuscript has been carefully reviewed to ensure its accuracy, and the authors are solely responsible for the integrity and final content of the manuscript.

REFERENCES

- Almulla, M. A. (2023). Constructivism learning theory: A paradigm for students' critical thinking, creativity, and problem solving to affect academic performance in higher education. *Cogent Education*, 10(1), Article 2172929. <https://doi.org/10.1080/2331186X.2023.2172929>
- Baah, C., Govender, I., & Rontala Subramaniam, P. (2024). Enhancing learning engagement: A study on gamification's influence on motivation and cognitive load. *Education Sciences*, 14(10), Article 1115. <https://doi.org/10.3390/educsci14101115>
- Esteban, A. J. (2024). Theories, principles, and game elements that support digital game-based language learning (DGBLL): A systematic review. *International Journal of Learning, Teaching and Educational Research*, 23(3), 1–22.
- Evans, P., Vansteenkiste, M., Parker, P., Kingsford-Smith, A., & Zhou, S. (2024). Cognitive load theory and its relationships with motivation: A self-determination theory perspective. *Educational Psychology Review*, 36(1), Article 7. <https://doi.org/10.1007/s10648-023-09841-2>
- Ghozali, I., & Latan, H. (2020). *Partial least squares: Konsep, teknik dan aplikasi menggunakan program SmartPLS 3.0* [Partial least squares: Concepts, techniques, and applications using SmartPLS 3.0]. Badan Penerbit Universitas Diponegoro.

- Guay, F. (2022). Applying self-determination theory to education: Regulations types, psychological needs, and autonomy supporting behaviors. *Canadian Journal of School Psychology*, 37(1), 75–92. <https://doi.org/10.1177/08295735211055355>
- Hamadneh, B., Fikry, A., Talaat, M., Abbas, A., & Ghanem, R. (2025). Exploring university students' perceptions and engagement in game-based learning. *International Journal of Evaluation and Research in Education*, 14(1), 525–534. <https://doi.org/10.11591/ijere.v14i1.30494>
- Irhad, A. I., & Ismail, W. (2023). Game-based learning media and its effect toward students' learning achievement. *Jurnal Pena Sains*, 10(1), 34–40. <https://doi.org/10.21107/jps.v10i1.16522>
- Jääskä, E., Lehtinen, J., Kujala, J., & Kauppara, O. (2022). Game-based learning and students' motivation in project management education. *Project Leadership and Society*, 3, Article 100055. <https://doi.org/10.1016/j.plas.2022.100055>
- Knowles, M. S., Holton, E. F., & Swanson, R. A. (2015). *The adult learner: The definitive classic in adult education and human resource development* (8th ed.). Routledge.
- Kompas. (2025). *Angka kecelakaan kerja di Indonesia: Ratusan ribu kasus tiap tahun* [Work accident rate in Indonesia: Hundreds of thousands of cases each year] [Instagram post]. Instagram. <https://www.instagram.com/p/DNp9aI8S47S/>
- Kovalchuk, V., Maslich, S., Tkachenko, N., Shevchuk, S., & Shchypyska, T. (2022). Vocational education in the context of modern problems and challenges. *Journal of Curriculum and Teaching*, 11(8), 329–338. <https://doi.org/10.5430/jct.v11n8p329>
- Li, J., & Pilz, M. (2023). International transfer of vocational education and training: A literature review. *Journal of Vocational Education & Training*, 75(2), 185–218. <https://doi.org/10.1080/13636820.2020.1847566>
- Lubis, F. S. R., Yasin, K. A., Baazir, F., & Purba, S. H. (2024). Studi literatur: Hubungan pengetahuan K3 dengan kejadian kecelakaan kerja [Literature study: The relationship between OHS knowledge and work accidents]. *Inovasi Kesehatan Global*, 1(3), 1–7. <https://doi.org/10.62383/ikg.v1i3.493>
- Manley, S. C., Hair, J. F., Williams, R. I., & McDowell, W. C. (2021). Essential new PLS-SEM analysis methods for your entrepreneurship analytical toolbox. *International Entrepreneurship and Management Journal*, 17(4), 1805–1825. <https://doi.org/10.1007/s11365-020-00687-6>
- McCambridge, J., Witton, J., & Elbourne, D. R. (2014). Systematic review of the Hawthorne effect: New concepts are needed to study research participation effects. *Journal of Clinical Epidemiology*, 67(3), 267–277. <https://doi.org/10.1016/j.jclinepi.2013.08.015>
- McGrath, S., & Yamada, S. (2023). Skills for development and vocational education and training: Current and emergent trends. *International Journal of Educational Development*, 102, Article 102853. <https://doi.org/10.1016/j.ijedudev.2023.102853>
- Nadeem, M., Oroszlanyova, M., & Farag, W. (2023). Effect of digital game-based learning on student engagement and motivation. *Computers*, 12(9), Article 177. <https://doi.org/10.3390/computers12090177>
- Neerupa, C., & William, A. J. (2024). Game on for learning: A holistic exploration of gamification's impact on student engagement and academic performance in educational environments. *Management Matters*, 21(1), 38–53. <https://doi.org/10.1108/MANM-01-2024-0001>
- Nguyen-Viet, B., & Nguyen-Viet, B. (2023). Enhancing satisfaction among Vietnamese students through gamification: The mediating role of engagement and learning effectiveness. *Cogent Education*, 10(2), Article 2265276. <https://doi.org/10.1080/2331186X.2023.2265276>

- Nusairat, N. M., Al-Qaisi, S., Shater, A., Hammouri, Q., Al-Dweeri, R. M., Al-Gasawneh, J. A., Fadlallah, H. R., & Darawsheh, S. R. (2024). Game-based student e-learning experience: Empirical evidence from private universities in Jordan. *International Journal of Data and Network Science*, 8(2), 1285–1292. <https://doi.org/10.5267/j.ijdns.2023.11.006>
- Podsakoff, P. M., MacKenzie, S. B., & Podsakoff, N. P. (2012). Sources of method bias in social science research and recommendations on how to control it. *Annual Review of Psychology*, 63, 539–569. <https://doi.org/10.1146/annurev-psych-120710-100452>
- Pum, M. (2025). Examining the predictive role of weekly game-based online quiz performance on academic achievement and engagement. *Asian Journal of Distance Education*, 20(2), 25–38.
- Sekaran, U., & Bougie, R. (2016). *Research methods for business: A skill-building approach* (7th ed.). John Wiley & Sons.
- Setiawan, P., Wibowo, K., & Satrio, E. M. (2023). Sistem manajemen keselamatan dan kesehatan kerja (SMK3) pada proyek pembangunan gedung Hotel Santika Nagrak Sukabumi [Occupational safety and health management system in the Santika Nagrak Sukabumi hotel construction project]. *Jurnal Ilmiah Mahasiswa Unissula*, 1(1). <https://jurnal.unissula.ac.id/index.php/JIMU/article/download/46650/13072>
- Sugiyono. (2022). *Metode penelitian kuantitatif* [Quantitative research methods] (3rd ed.). Alfabeta.
- THE Journal. (2025, June 24). *Quizizz rebrands as Wayground, announces new AI features*. <https://thejournal.com/Articles/2025/06/24/Quizizz-Rebrands-as-Wayground-Announces-New-AI-Features.aspx>
- Videnovik, M., Vold, T., Kjøning, L., Bogdanova, A. M., & Trajkovic, V. (2023). Game-based learning in computer science education: A scoping literature review. *International Journal of STEM Education*, 10, Article 54. <https://doi.org/10.1186/s40594-023-00447-2>
- Wardoyo, C., Satrio, Y. D., Narmaditya, B. S., & Wibowo, A. (2021). Do technological knowledge and game-based learning promote students achievement: Lesson from Indonesia. *Heliyon*, 7(11), Article e08467. <https://doi.org/10.1016/j.heliyon.2021.e08467>
- Youssef, E., Medhat, M., Abdellatif, S., & Al Malek, M. (2024). Examining the effect of ChatGPT usage on students' academic learning and achievement: A survey-based study in Ajman, UAE. *Computers and Education: Artificial Intelligence*, 7, Article 100316. <https://doi.org/10.1016/j.caeai.2024.100316>
- Zhang, Q., & Yu, Z. (2022). Meta-analysis on investigating and comparing the effects on learning achievement and motivation for gamification and game-based learning. *Education Research International*, 2022, Article 1519880. <https://doi.org/10.1155/2022/1519880>
- Zubair, M. U., Khan, M. A., Hassan, M. U., Ahmed, K., & Aziz, T. (2024). Enhancing student active engagement in class through game-based learning: A case of civil engineering education. *Sustainability*, 16(14), Article 6010. <https://doi.org/10.3390/su16146010>