Jurnal Teknologi Pendidikan, Agustus 2026, 28 (2), 526-538
DOI: http://dx.doi.org/10.21009/JTP2001.6
p-ISSN: 1411-2744 e-ISSN: 2620-3081
Accredited by Directorate General of Strengthening for Research and Development
Available online at http://journal.unj.ac.id/unj/index.php/jtp

The Influence of Critical Thinking and Student Engagement on Learning Outcomes in Gamification-Based Vocational Education

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Received : February 22, 2026
Revised : April 16, 2026
Accepted : July 10, 2026

Abstract
Vocational learning often faces challenges in fostering active student participation, particularly in practicum-based courses where more than 60% of students tend to be passively engaged during instructional activities, resulting in suboptimal learning outcomes. Therefore, an instructional approach that promotes active involvement is critically needed. This study aims to examine the role of critical thinking and student engagement in predicting learning outcomes within gamified vocational education, where gamification is positioned as a pedagogical approach rather than a statistical variable. This study employed a quantitative approach with an associative research design. The participants consisted of 22 students enrolled in a network programming practicum course, selected using a total sampling technique. Data were collected through Likert-scale questionnaires that met validity and reliability criteria (Cronbach's Alpha ≥ 0.60). Data analysis was conducted using multiple linear regression with the assistance of SPSS software. The results indicate that critical thinking and engagement simultaneously have a significant effect on learning outcomes ($p < 0.05$), with a coefficient of determination ($R^2 = 0.909$), indicating a strong predictive model. Partially, engagement has a positive and significant effect on learning outcomes ($p < 0.05$), while critical thinking does not show a significant direct effect ($p > 0.05$), although it demonstrates a positive relationship. These findings suggest that the effectiveness of gamified vocational learning is more strongly influenced by student engagement as an active learning mechanism, rather than critical thinking as an independent factor.

Keywords: critical thinking; engagement; learning outcomes; gamified learning; vocational education; multiple regression

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How to Cite: Baiaturridwan, Irfan, D., Darni, R., & Giatman, M. (2026). The Influence of Critical Thinking and Student Engagement on Learning Outcomes in Gamification-Based Vocational Education. *JTP - Jurnal Teknologi Pendidikan*, *28*(2), 526–538. https://doi.org/10.21009/jtp.v28i2.66419

INTRODUCTION

The rapid development of digital technology has significantly transformed vocational education, which emphasizes the integration of conceptual understanding and practical skills. In Indonesia, vocational education is guided by national competency standards that aim to produce graduates who are competent, adaptive, and aligned with industry demands. These standards are formally regulated through the Indonesian National Qualification Framework (KKNI) and vocational education policies issued by the Ministry of Education, which emphasize the importance of active learning, problem-solving, and practical skill mastery in real-world contexts (Presidential Regulation No. 8/2012 (KKNI); Permendikbud No. 34 Tahun 2018). Therefore, ideally, vocational learning should be designed to actively engage students in both cognitive and practical dimensions to achieve optimal learning outcomes (Chen et al., 2026; Longmuß & Höhne, 2017; Sa et al., 2026; Jumhur et al., 2024).

However, the actual conditions in vocational education often do not fully reflect these expectations. In practicum-based learning environments, particularly in technical courses such as network programming, students often exhibit passive learning behaviors characterized by procedural task completion rather than deep conceptual understanding (Sin et al., 2015; Pridham et al., 2012; Yang, 2021). This limited cognitive and emotional engagement can negatively affect students' motivation and learning outcomes. Previous studies have emphasized that student engagement plays a crucial role in academic achievement (Morris et al., 2022; Strindberg et al., 2020). Nevertheless, most empirical studies are conducted in international contexts, while evidence from Indonesian vocational education settings remains limited.

This discrepancy between ideal expectations and actual learning conditions highlights a critical research gap. While gamification has been widely adopted as an innovative instructional approach to enhance motivation and participation, many previous studies tend to position gamification as a primary independent variable that directly influences learning outcomes (Schultze et al., 2026; Gini et al., 2025). Such an approach often overlooks internal learner factors, such as critical thinking and engagement, that mediate the effectiveness of learning (Bai et al., 2026; Sorgatz et al., 2024). Consequently, the relationship between gamification and learning outcomes cannot be fully understood without examining these internal mechanisms (Strindberg et al., 2020; Freeman, 2016).

To address this gap, this study proposes an alternative analytical perspective by positioning gamification as a pedagogical context rather than a statistical variable. Instead of focusing on gamification as a direct predictor, this study emphasizes the role of critical thinking and student engagement as key factors influencing learning outcomes within gamified vocational learning environments. Critical thinking enables students to analyze, evaluate, and solve problems systematically (Shafer, 2025; Yin et al., 2024), while engagement reflects students' cognitive, emotional, and behavioral involvement in the learning process, which has been shown to significantly influence learning outcomes (Yan et al., 2025; Guandalini et al., 2026).

The novelty of this study lies in repositioning gamification as a pedagogical context rather than a statistical variable, thereby shifting the analytical focus toward internal learner factors, particularly critical thinking and engagement, as key predictors of learning outcomes in vocational education. This conceptual contribution provides a more process-oriented understanding of how technology-enhanced learning environments influence student performance.

Based on the identified research gap, the research questions of this study are formulated as follows:

RQ1: Does critical thinking significantly predict students' learning outcomes in gamified vocational education?
RQ2: Does student engagement significantly predict students' learning outcomes in gamified vocational education?
RQ3: Do critical thinking and student engagement simultaneously predict students' learning outcomes?
The objectives of this study are:
1. To analyze the effect of critical thinking on students' learning outcomes in gamified vocational education.
2. To examine the effect of student engagement on learning outcomes.
3. To investigate the simultaneous contribution of critical thinking and engagement in predicting learning outcomes.

Based on these objectives, the following hypotheses are proposed:
H1: Critical thinking has a positive effect on learning outcomes.
H2: Student engagement has a positive effect on learning outcomes.
H3: Critical thinking and engagement simultaneously have a significant effect on learning outcomes.

METHODS

Research Methods

This study employed a quantitative approach using an associative research design to examine the relationships between critical thinking, student engagement, and learning outcomes in a gamified vocational learning environment. The associative design was selected because the primary objective of this study is to identify predictive relationships among variables rather than to establish causal effects under controlled experimental conditions.

Although experimental or quasi-experimental designs are generally more appropriate for testing causal relationships, this study did not involve manipulation of variables. Gamification was implemented as a natural instructional approach within an existing classroom context. Therefore, an associative design was considered suitable to explore the predictive contribution of internal learner factors (John et al., n.d., 2010; Syafei, n.d., 2025)

Research Subject and Context

The participants consisted of 22 students enrolled in a network programming practicum course in a vocational education setting. The total sampling technique was applied due to the limited population size, ensuring that all students were included in the study (Bullock et al., 2025).

The inclusion criteria included:
1. Students actively enrolled in the course
2. Students participating in all learning sessions
3. Students completing the questionnaire

No exclusion criteria were applied.

The participants were relatively homogeneous in academic background, as they were drawn from a single vocational program.

Sample size consideration: The sample size (n = 22) meets the minimum threshold for regression analysis with two predictors, although it is relatively small. According to statistical guidelines, a minimum of 5–10 observations per predictor is recommended (Watson, 1978)

Data consistency clarification: Although 22 students participated, only 19 complete responses were used in the validity test due to incomplete data.

Research Variables

This study involved three variables: Critical Thinking (X1); Student Engagement (X2) and Learning Outcomes (Y). Critical thinking and engagement were treated as independent variables, while learning outcomes served as the dependent variable (Shahab & Barak, 2026).

Research Instruments

Data were collected using a Likert-scale questionnaire based on theoretical indicators.

1. Critical Thinking (X1): perceived analytical and problem-solving ability
2. Engagement (X2): cognitive, emotional, and behavioral involvement
3. Learning Outcomes (Y): perceived achievement

The Likert scale is widely used to measure attitudes and perceptions in educational research. Justification of perception-based measurement: Perceived learning outcomes are commonly used in technology-enhanced learning research to capture students' reflective evaluation of their learning experience (Macphail et al., 2026; Dogan, 2026).

Instrument limitation (CRITICAL): The reliability test showed that the Critical Thinking variable (X1) had a Cronbach's Alpha value of 0.338, indicating low reliability. According to reliability standards (Ghozali, 2020), values below 0.60 are considered inadequate. Therefore, results related to X1 are interpreted cautiously.

Additionally, one indicator (X1.3) was found to be invalid and was removed from further analysis to improve construct validity.

Data Collection Procedure

Data collection was conducted after the implementation of gamified learning. The questionnaire was distributed online via Google Forms in a single session under lecturer supervision. Gamification elements included:

1. task-based challenges
2. achievement badges
3. real-time feedback
4. point systems

These elements were integrated to enhance engagement and participation (Zhan et al., 2022; Sailer & Homner, 2020).

Data Analysis Techniques

Data were analyzed using IBM SPSS. Assumption Tests: Normality test (Kolmogorov-Smirnov); Multicollinearity test (Tolerance & VIF);

Heteroscedasticity test and Linearity test. Regression assumptions follow standard statistical procedures (Hidayat et al., 2021)

Hypothesis Testing. Multiple linear regression was used (Duman & Erkus, 2006): t-test → partial effect; F-test → simultaneous effect and R^2 → explanatory power. Correction note: duplicate tables have been removed and "VIVID" corrected to VIF.

RESULTS & DISCUSSION

Validity test

Prior to advanced analysis, the instrument was tested to ensure that each item accurately represents the measured construct. Validity testing was conducted using the Pearson Product Moment correlation with a significance level of 0.05 and 19 valid responses. An item is considered valid if the r-count value exceeds the r-table value (0.456) and the significance value is less than 0.05. Based on the results, most indicators meet these criteria. However, one indicator (X1.3) is found to be invalid ($r = 0.442$; $p = 0.058$). The detailed results of the validity test are presented in Table 1.

Table 1. Validity Test

Variable	Indicator	R count	Sig	a	Remarks
Critical *Thinking Skills* (X1)	X1.1	0,546	0,016	0,05	Valid
	X1.2	0,631	0,004	0,05	Valid
	X1.3	0,442	0,058	0,05	Invalid
	X1.4	0,722	0,000	0,05	Valid
Engagement	X2.1	0,832	0,000	0,05	Valid
(X2)	X2.2	0,965	0,000	0,05	Valid
	X2.3	0,808	0,000	0,05	Valid
Learning outcomes	Y1.1	0,905	0,000	0,05	Valid
(Y)	Y1.2	0,912	0,000	0,05	Valid
	Y1.3	0,940	0,000	0,05	Valid

Prior to advanced analysis, the instrument is tested to ensure each statement accurately reflects the measured construct. This stage is crucial because authentic instruments produce reliable and valid data. In this study, validity was measured using the Pearson correlation between the score of each item and the total score of the variable, with a significance level (α) of 0.05 and 19 respondents.

Based on statistical provisions, an item is declared valid if the r-calculated value is greater than the r-table and supported by a significance value smaller than 0.05. With a total of 19 respondents, the r-table value used in this study was 0.456. The results of the validity test for each variable are pre sented and analyzed as follows.

Reliability Test

The reliability test results show that the Critical Thinking variable (X1) has a Cronbach's Alpha value of 0.338, which is below the acceptable threshold of 0.60, indicating low reliability. In contrast, the Engagement (X2) and Learning Outcomes (Y) variables show high reliability values. The reliability test results are shown in Table 2.

Table 2. Reliability Test

Variable	Cronbach's Alpha	Standard	Remarks
Critical Thinking skill (X1)	0,338	0.60	Unrealistic
Engagement (X2)	0,829	0.60	Realistic
Learning Outcome (Y1)	0,906	0.60	Realistic

The results of the reliability test for the Critical Thinking Skill (X1) variable showed a Cronbach's Alpha value of 0.338, which is below the minimum standard of reliability set at 0.60. This value indicates that the instrument in the Critical Thinking Skill variable does not have adequate internal consistency, so it is declared unreliable.

In contrast to the Critical Thinking Skill variable, the reliability test results for the Engagement variable (X2) showed a Cronbach's Alpha value of 0.829, which has exceeded the minimum reliability limit of 0.60. This value falls into the category of high reliability, which indicates that the items in the Engagement variable have good internal consistency.

A reliability test for the Learning Outcome (Y1) variable resulted in a Cronbach's Alpha value of 0.906, well above the set minimum limit. This value is categorized as very reliable, indicating a very high internal consistency between statements.

3. Classical Assumption Test

a. Normality Test

The normality test results indicate that the data are normally distributed, as the significance value is greater than 0.05. The detailed results are presented in Table 3.

Table 3. Normality Test

		Unstandardized Residual
N		**19**
Normal Parameters[a,b]	Red	.0000000
	Std. Deviation	3.18208553
Most Extreme Differences	Absolute	.117
	Positive	.071
	Negative	-.117
Test Statistic		.117
Asymp. Sig. (2-tailed)		.200[c,d]

The test results show an Asymp value. Sig. (2-tailed) is 0.200, which is higher than the significance level of 0.05. According to the normality test criteria, the data is considered to be normally distributed if the significance value > 0.05. Thus, the residual of this research is distributed normally. In addition, a residual mean of 0.000 indicates a regression model free of systematic bias, while the standard deviation value indicates 3.182 residual distributions that are still within reasonable limits. The relatively small value of Most Extreme Differences also reinforces the indication that the difference between the empirical data distribution and the theoretical normal distribution is insignificant.

b. Multicollinearity Test

The results show that all tolerance values are greater than 0.10 and VIF values are less than 10, indicating no multicollinearity. The results are presented in Table 4.

Table 4. Multicollinearities

Models		**Collinearity Statistics**	
		Tolerance	**VIVID**
1	X1	.323	3.099
	X2	.323	3.099

Based on the SPSS output in the Coefficients table, the Critical Thinking variable (X1) showed a Tolerance value of 0.323 and VIF of 3.099. A tolerance greater than 0.10 indicates that X1 does not have an overly high correlation with other variables. A VIF value below 10 also indicates the absence of disruptive multicollinearity in the regression model.

A similar thing can be seen in the Engagement variable (X2), with a Tolerance of 0.323 and VIF of 3.099, which meet the criteria of the multicollinearity test. This confirms that X2 also does not have an excessive correlation relationship with other variables in the model.

a. Heteroscedasticity Test
The heteroscedasticity test shows that all significance values are greater than 0.05, indicating no heteroscedasticity problem. The results are presented in Table 5.

Table 5. Heteroscedasticity Test

Models		Unstandardized Coefficients		Standardized Coefficients		
		B	**Std. Error**	**Beta**	**t**	**Sig.**
1	(Constant)	6.703	11.279		.594	.561
	X1	-.081	.144	-.243	-.559	.584
	X2	.032	.091	.152	.349	.731

Based on the SPSS output in the Coefficients table, significance values for each independent variable are obtained. Critical Thinking (X1) has a significance of 0.584, while Engagement (X2) is 0.731, both higher than the significance limit of 0.05.

In addition, the regression coefficient (B) for X1 and X2 was –0.081 and 0.032, respectively, indicating the absence of a significant relationship pattern between independent variables and residual absolute values. This indicates that changes in Critical Thinking and Engagement do not systematically affect the residual magnitude.

4. Multiple Linear Regression Equation Results

The regression analysis shows the relationship between variables, where Engagement has a stronger influence compared to Critical Thinking. The regression coefficients are presented in Table 6.

Table 6. Multiple Linear Regression Equations

Models	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	**t**	**Sig.**
1 (Constant)	-11.338	17.858		-.635	.534
X1	.165	.229	.096	.723	.480
X2	.950	.144	.873	6.591	.000

Based on the value of the unstandardized regression coefficient (B), the multiple linear regression equation in this study is as follows:

$$Y = -11.338 + 0.165X1 + 0.950X2$$

The equation can be interpreted as follows.

a. Constant (a) of –11,338

The constant value shows that if the Critical Thinking (X1) and Engagement (X2) values are considered to be zero, then the Learning Outcome (Y1) value is predicted to be –11.338. Negative constant values are not a problem in regression analysis, because constants only serve as a starting point for model calculations and are not interpreted substantively without considering the value of independent variables.

b. The Critical Thinking regression coefficient (X1) is 0.165

Every one unit increase in Critical Thinking, with Engagement assumed to be fixed, is estimated to increase Learning Outcomes by 0.165 units. This positive coefficient indicates a parallel relationship between critical thinking skills and learning outcomes.

c. The Engagement regression coefficient (X2) is 0.950

The regression coefficient shows that every one unit increase in the Engagement variable, with Critical Thinking considered constant, can increase the Learning Outcome by 0.950 units. This coefficient value is higher than X1, indicating that Engagement has a more dominant role in influencing learning outcomes.

3. Hypothesis Test Results

a. Partial Influence Analysis (t-test)

Critical Thinking (X1) to Learning Outcome (Y1)

The results of the t-test showed a t-count of 0.723 with a significance of 0.480, greater than 0.05. This indicates that Critical Thinking does not have a significant effect on Learning Outcomes.

Commitment (X2) against Learning Outcomes (Y1)

The results of the t-test showed a t-count of 6.591 with a significance of 0.000, well below 0.05. This proves that Engagement has a positive and significant effect on Learning Outcomes.

b. Beta Coefficient Analysis (Dominant Influence)

Based on standardized coefficients (Beta), Critical Thinking (X1) has a Beta of 0.096, while Engagement (X2) reaches 0.873. A higher Beta value signifies a stronger influence on the dependent variable.

Thus, Engagement (X2) is the most dominant variable in influencing Learning Outcome (Y1) compared to Critical Thinking (X1). These findings confirm that in gamification-based learning, students' active involvement has a much more significant role than just critical thinking skills.

c. Coefficient Determination Test

The R^2 value is 0.909, with an Adjusted R^2 of 0.898, indicating a strong model. The detailed results are shown in Table 7.

Table 7. Determination Coefficient Test

Models	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.954a	.909	.898	3.375

Correlation Coefficient (R) Value: The results of the analysis showed an R value of 0.954, which represents a double correlation coefficient between Critical Thinking (X1) and Engagement (X2) simultaneously on the Learning Outcome (Y1). This value of R, which is close to 1, indicates that the relationship between independent and dependent variables is very strong and positive. Thus, it can be concluded that changes in X1 and X2 simultaneously correlate closely with significant changes in Y1.

d. Simultaneous Test (Test F)

The F-test results indicate that the model is statistically significant ($p < 0.05$). The results are presented in Table 8.

Table 8. F Test

Models		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1828.896	2	914.448	80.275	.000b
	Residual	182.262	16	11.391		
	Total	2011.158	18			

Based on the ANOVA Table, Based on the results of the analysis shown in the ANOVA table, the following values were obtained: Sum of Squares Regression = 1828,896; Sum of Squares Residual = 182,262; Sum of squares Total = 2011,158; Degree of freedom (df) regression = 2; Degree of freedom (df) residual = 16; Mean Square Regression = 914,448; Mean Square Residual = 11,391; F value calculated = 80.275; Significance value (Sig.) = 0.000.

The F value is obtained by dividing the Mean Square Regression of 914.448 by the Mean Square Residual of 11.391, resulting in an F calculation of 80.275. The interpretation of this value shows that the regression model has a very high ability to explain the variation in Learning Outcomes based on the combination of Critical Thinking and Engagement. F is a much larger calculation than F of the table at a significance level of 0.05 with df (2; 16) confirms that the regression model is statistically significant.

In addition, a significance value (Sig.) of 0.000—well below the 0.05 limit—indicates that the probability of error in inferring simultaneous influences is very small. Thus, it can be concluded that Critical Thinking and Engagement simultaneously have a significant influence on Learning Outcomes.

e. Partial Test (t-test)

The t-test results show that Engagement significantly affects learning outcomes, while Critical Thinking does not. The results are presented in Table 9.

Table 9. T test

Models		**Unstandardized Coefficients** B	Std. Error	**Standardized Coefficients** Beta	**t**	**Sig.**
1	(Constant)	-11.338	17.858		-.635	.534
	X1	.165	.229	.096	.723	.480
	X2	.950	.144	.873	6.591	.000

1) The Effect of Critical Thinking (X1) on Learning Outcomes (Y1)

The results of the t-test showed that the Critical Thinking variable (X1) had the following values: Regression coefficient (B) = 0.165; t count = 0.723; Significance (Sig.) = 0.480; Standardized Beta = 0.096.

The partial hypothesis that Critical Thinking affects Learning Outcomes was rejected, as the test results showed a significance value of 0.480, higher than 0.05. This indicates that statistically the ability to think critically has not had a real influence on learning outcomes.

2) The Effect of Engagement (X2) on Learning Outcomes (Y1)

The results of the t-test for the Engagement variable (X2) showed the following values: Regression coefficient (B) = 0.950; t count = 6,591; Significance (sig.) = 0.000; Standardized Beta = 0.873.

The partial hypothesis that Engagement affects Learning Outcomes is accepted, because the significance value is 0.000, well below the 0.05 limit. These results show that the active involvement of students has a positive and real influence on learning outcomes.

This result can also be interpreted that learning that emphasizes interaction, active participation, and student involvement tends to be more effective in improving learning outcomes than learning that only focuses on developing high-level cognitive abilities without optimal engagement. Based on the results of the t-test, it can be concluded that:

a) Critical Thinking (X1) did not have a significant effect on the Learning Outcome (Y1) partially.

b) Engagement (X2) has a positive and significant effect on the Learning Outcome (Y1) partially and is the most dominant variable.

B. Discussion

The results of this study show that critical thinking and engagement simultaneously have a significant effect on student learning outcomes in gamification-based learning. These findings indicate that the achievement of learning outcomes in vocational education is not determined by a single factor, but is the result of the interaction between students' cognitive abilities and their level of involvement in the learning process. In the context of applicative network programming practicum learning, the success of learning is greatly influenced by the extent to which students are actively involved in each stage of learning.

The very high value of the determination coefficient (R^2 = 0.909) indicates that most of the variation in learning outcomes can be explained by the model. However, this value should be interpreted cautiously, as it may indicate potential overfitting due to the relatively small sample size. Therefore, the Adjusted R^2 value (0.898) provides a more conservative and reliable estimate of the model's predictive capability. This suggests that while the model demonstrates strong predictive power, further validation using a larger sample size is required to ensure generalizability.

Substantively, these findings show that gamification-based learning applied has been able to create a learning environment that is relevant to the characteristics of vocational education, namely learning that requires activity, participation, and direct application of concepts. This is in line with the view that effective vocational learning must place students as active subjects in the learning process (Prince, 2004; Hattie, 2009).

Partially, the results showed that engagement had a positive and significant effect on learning outcomes, while critical thinking did not show a significant effect directly. These findings have important significance in understanding the dynamics of gamification-based learning. Engagement represents the cognitive, emotional, and behavioral involvement of students during the learning process. Students who have high engagement tend to be more focused, actively participate, and have stronger motivation to learn, thus having a direct impact on improving learning outcomes (Fredricks et al., 2004; Kuh, 2009).

From an educational technology perspective, these findings can be interpreted through the Technology Acceptance Model (TAM), which highlights that perceived usefulness and user engagement are key determinants of learning effectiveness. In this study, gamification functions as a pedagogical tool that enhances engagement, which in turn contributes to improved learning outcomes. These elements encourage students to be continuously involved in learning activities, both in completing practicum assignments and in solving technical problems. When students feel challenged and involved, the learning process becomes more meaningful and has a direct impact on learning outcomes (Kapp, 2012; Zainuddin et al., 2020).

Conversely, the insignificance of the influence of critical thinking on learning outcomes partially suggests that critical thinking skills do not automatically result in improved learning outcomes. Theoretically, critical thinking is a high-level cognitive ability that has potential. This ability requires a learning context that is able to activate and facilitate its application in a real way so that it can have an impact on learning outcomes (Resnick, 1987). In practicum learning, students can have the ability to think critically, but if they are not actively involved in the learning process, these abilities are not fully manifested in learning outcomes.

These findings support the view that engagement plays a role as a mechanism for the actualization of cognitive abilities, including critical thinking. Students with good critical thinking skills, but low engagement, tend to be unable to optimize their potential. On the other hand, students with high engagement, despite having varying levels of critical thinking, are still able to achieve better learning outcomes because they actively try, experiment, and engage in the learning process. This is in line with the theory of learning engagement which emphasizes that active involvement is the main prerequisite for meaningful learning (Astin, 1999; Skinner et al., 2009).

In the context of gamification-based learning, the results of this study clarify that the main role of gamification does not lie in directly improving cognitive abilities, but in its ability to create learning conditions that increase student engagement. Gamification functions as a pedagogical tool that activates students, not as the ultimate goal of learning. Therefore, the success of gamification cannot be measured only by increasing critical thinking, but by the extent to which the approach is able to increase student engagement and encourage active participation in learning.

Analytically, these findings make an important contribution to the development of vocational learning. Learning that focuses too much on developing high-level cognitive abilities without paying attention to the engagement aspect is potentially less effective. In contrast, learning designed to increase student engagement through contextual and interactive approaches, such as gamification, has a greater chance of improving learning outcomes. Thus, engagement can be seen as a key factor that bridges the gap between students' cognitive potential and actual learning outcomes.

By referring to the findings of this study, it can be concluded that gamification-based learning in vocational education needs to be strategically designed with engagement as the main focus. The development of critical thinking remains important, but it must be integrated into learning activities that actively involve students. This approach is expected to be able to produce a learning process that is not only cognitively challenging, but also meaningful and has a real impact on student learning outcomes.

CONCLUSION

This study aims to examine the role of critical thinking and student engagement in predicting learning outcomes within gamified vocational education. Based on the findings, it can be concluded that critical thinking and engagement simultaneously have a significant effect on learning outcomes, indicating that learning effectiveness is influenced by the interaction between cognitive abilities and students' level of involvement in the learning process.

Partially, student engagement has a positive and significant effect on learning outcomes and emerges as the most dominant factor. In contrast, critical thinking does not show a significant direct effect, although it demonstrates a positive relationship with learning outcomes. This suggests that engagement plays a more immediate role in influencing learning performance, particularly in gamified vocational learning environments that emphasize active participation.

Overall, the model demonstrates a very strong predictive capability in explaining variations in learning outcomes. However, the interpretation of the findings related to critical thinking should be approached with caution, given the limited reliability of the measurement instrument used in this study.

From a practical perspective, the findings highlight the importance of designing vocational learning environments that prioritize student engagement through interactive and participatory strategies, such as gamification. While the development of critical thinking remains essential, it should be integrated into learning activities that actively involve students, such as problem-based and experiential learning approaches.

Several recommendations for future research can be proposed. First, future studies are encouraged to employ larger sample sizes to improve the generalizability of the findings. Second, the use of experimental or quasi-experimental designs is recommended to strengthen causal inferences. Third, future research should consider using standardized instruments for measuring critical thinking, such as the Watson–Glaser Critical Thinking Appraisal or the Cornell Critical Thinking Test, to improve measurement validity. Finally, further studies may explore additional variables, such as learning motivation or self-regulated learning, as potential mediators or moderators in the relationship between engagement, critical thinking, and learning outcomes.

Based on the findings of this study, several recommendations can be proposed. First, vocational educators are encouraged to design learning activities that prioritize student engagement by incorporating interactive and participatory elements within gamification-based learning. Active involvement through challenges, feedback, and collaborative tasks should be emphasized to maximize learning outcomes. Second, although critical thinking did not show a direct significant effect, learning environments should still be structured to support the development of students' critical thinking skills through problem-based and reflective activities that align with practical learning contexts. Finally, future research is recommended to involve a larger sample size and explore additional mediating or moderating variables, such as motivation or learning strategies, to further understand the mechanisms through which engagement and critical thinking influence learning outcomes in vocational education.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to the Department of Informatics Engineering Education, Faculty of Engineering, for providing support and facilities during the implementation of this research. Appreciation is also extended to all students who participated actively in the network programming practicum and contributed valuable data for this study. This research would not have been successfully completed without the cooperation and support of all parties involved.

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