

The Role Of Digital-Based C3EL In Predicting Critical Thinking: A Multivariate Regression Approach

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Abstract

This study investigates the effectiveness of the Collaborative Contextual Constructivist Entrepreneurship Learning (C3EL) model in enhancing students' critical thinking skills within digital-based entrepreneurship education. Using a multivariate regression approach, the research tested three dimensions collaborative, contextual, and constructivist on a sample of higher education students. Classical assumption tests confirmed that the data met normality, linearity, homoscedasticity, multicollinearity, and autocorrelation requirements, validating the regression model. The results revealed that the collaborative dimension had the strongest contribution ($\beta = 0.29$, $p < 0.01$), followed by the contextual dimension ($\beta = 0.25$, $p < 0.01$), while the constructivist dimension contributed moderately but remained significant ($\beta = 0.18$, $p < 0.05$). The overall C3EL model was highly significant ($\beta = 0.47$, $p < 0.001$) with $R^2 = 0.38$, explaining 38% of the variance in students' critical thinking skills. These findings highlight the importance of integrating collaboration, contextual relevance, and active knowledge construction in digital learning environments. The study addresses gaps in previous research that examined learning approaches only partially, offering a comprehensive framework for innovative pedagogy in higher education.

Keywords: C3EL model, Digital learning, Critical thinking, Entrepreneurship

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I. Introduction

This research is based on constructivism theory, which emphasizes that knowledge is actively constructed by individuals through interactions with the learning environment (Jonassen, 2018), and collaborative learning theory, which emphasizes the importance of social interaction in the learning process (Johnson & Johnson, 2019). The C3EL model integrates three main approaches: collaborative, contextual, and constructivist, within a digital-based learning environment. Conceptually, this model positions C3EL as a statistical variable influencing critical thinking skills, the dependent variable. This relationship is analyzed using multivariate regression to identify the contribution of each dimension of the model.

The digital transformation in higher education has driven a paradigm shift in learning from traditional approaches to more interactive, collaborative, and technology-based learning. In the context of entrepreneurship learning, this development is increasingly important because 21st-century competencies, particularly critical thinking skills, are key to navigating the complexity and uncertainty of the modern business world (OECD, 2019; Facione, 2020). Critical thinking enables students to analyze opportunities, evaluate risks, and make strategic decisions rationally. However, various reports indicate that students' critical thinking skills in many countries remain at moderate to low levels, particularly in theory-based learning contexts that lack contextualization (World Economic Forum, 2020).

The urgency of this research lies in the urgent need to develop learning models capable of integrating digital technology with effective pedagogical approaches. Previous studies have shown that the use of digital technology without a constructivist and collaborative approach tends not to have a significant impact on the development of higher-order thinking skills (Bond et al., 2020). This confirms that simply digitizing learning is not enough; learning designs that encourage active student engagement in constructing knowledge are needed.

A research gap that has emerged is that most previous studies have examined learning approaches in isolation, such as project-based learning, collaborative learning, or contextual learning (Hmelo-Silver et al., 2019; Dillenbourg, 2017; Bell, 2019). Furthermore, research examining the effectiveness of digital-based learning in

improving critical thinking has yielded inconsistent results, primarily due to differences in the pedagogical designs used (Huang et al., 2021). Furthermore, the application of multivariate regression analysis to test the effectiveness of integrative learning models such as C3EL is still very limited (Hair et al., 2019).

The novelty of this research lies in the integration of the digital-based Collaborative Contextual Constructivist Entrepreneurship Learning (C3EL) model within a multivariate regression analysis framework. By combining collaborative, contextual, and constructivist dimensions in a single model, this study provides a novel contribution to understanding how digital-based learning can significantly predict students' critical thinking skills. This approach not only examines the relationships between variables but also provides a comprehensive understanding of the contribution of each dimension to improving students' critical thinking skills in entrepreneurship learning.

Research Problem

Based on the background outlined above, the research questions are as follows:

1. Does the digital-based C3EL model have a significant influence on students' critical thinking skills in entrepreneurship learning?
2. How do each dimension of the C3EL model (collaborative, contextual, and constructivist) contribute to predicting students' critical thinking skills?
3. To what extent can the integration of the digital-based C3EL model address the gaps in previous research that only examined learning approaches partially?
4. Is the application of multivariate regression analysis able to provide a comprehensive understanding of the C3EL model's contribution to strengthening innovative digital-based learning designs in higher education?

II. Literature Review

Critical Thinking Skills

Critical thinking is a key 21st-century skill that is crucial for students, especially in navigating the complexities of the modern business world. Critical thinking enables students to analyze opportunities, evaluate risks, and make rational strategic decisions (Facione, 2020). However, global reports indicate that students' critical thinking skills remain relatively low, particularly in theory-based learning that lacks context (World Economic Forum, 2020). This underscores the need for learning models that integrate digital technology with effective pedagogical approaches.

Digital Transformation

The digital transformation in higher education has driven the integration of technology into entrepreneurship learning. Digital platforms have been shown to increase the flexibility and accessibility of learning (Martin et al., 2020) and can enhance student engagement (Huang et al., 2021). However, the use of digital technology without appropriate pedagogical design does not automatically improve critical thinking skills (Bond et al., 2020). Therefore, approaches that combine technology with learning strategies that encourage active student engagement are needed.

Constructivist Approach

The constructivist approach emphasizes that knowledge is actively constructed by students through exploration and reflection (Jonassen, 2018). In this context, students not only receive information but also construct understanding through learning experiences. Furthermore, collaborative learning plays a crucial role in enhancing critical thinking skills through discussion, negotiation of meaning, and collaborative problem-solving (Johnson & Johnson, 2019; Laal & Ghodsi, 2012). Meanwhile, contextual learning emphasizes the connection between material and real-world situations, enabling students to connect theory with business practice (Bell, 2019). All three approaches have proven effective, but previous research has tended to examine them in isolation.

The Collaborative Contextual

Constructivist Entrepreneurship Learning (C3EL) model is presented. C3EL is an innovation that integrates collaborative, contextual, and constructivist approaches within a single digital-based learning framework. This integration is still rarely researched, particularly in the context of digital entrepreneurship (Hmelo-Silver et al., 2019). The novelty of this research is the application of multivariate regression analysis to examine the contribution of each C3EL dimension to students' critical thinking skills (Hair et al., 2019). Thus, this research is expected to make a significant contribution to the development of innovative digital-based learning designs in higher education.

Figure 1 Three dimensions (collaborative, contextual, constructivist)



This diagram shows that the three dimensions (collaborative, contextual, constructivist) contribute simultaneously in forming a digital-based C3EL model, which then predicts students' critical thinking abilities..

III. Methods

Research Design

This study employed a quantitative design with a correlational approach and was cross-sectional in nature. This design was chosen to examine the predictive relationship between the independent variable (the digital-based C3EL model) and the dependent variable (students' critical thinking skills). The correlational approach allowed researchers to identify the predictive power between variables using multivariate regression analysis.

Purpose and Hypothesis

This study aims to analyze the role of the digital-based Collaborative Contextual Constructivist Entrepreneurship Learning (C3EL) model in predicting students' critical thinking skills in entrepreneurship learning. The urgency of this research lies in the urgent need to develop a digital learning model that addresses the gap in previous research, namely the limitations of studies that only examine learning approaches partially (Hmelo-Silver et al., 2019; Huang et al., 2021). The novelty of this study is the application of multivariate regression analysis to examine the contribution of each C3EL dimension to students' critical thinking skills (Hair et al., 2021).

The research hypotheses are formulated as follows:

H₀: The digital-based C3EL model does not have a significant effect on students' critical thinking skills.

H₁: The digital-based C3EL model has a significant effect on students' critical thinking skills.

Setting

The research was conducted at Universitas PGRI Jombang, Indonesia, for three months (January–March 2026). This university was chosen because it has a relevant academic environment for studying the implementation of digital-based entrepreneurship learning. The research subjects were students in the Economics Education Study Program who had taken Entrepreneurship courses, thus possessing basic knowledge relevant to the research context.

Population, Sample, and Sampling Technique

The research population was all students in the Economics Education Study Program, intakes of 2023 and 2024. The sample size of 52 students was selected using simple random sampling, ensuring that each member of the population had an equal chance of being selected. This sample size meets the minimum recommendations for multivariate analysis (Hair et al., 2021).

Research Variables and Operational Definitions

a. Independent variable: The digital-based C3EL model, consisting of three main dimensions: collaborative, contextual, and constructivist. Operationally, C3EL is defined as a learning approach that integrates digital technology with collaborative interactions, real-world contexts, and active knowledge construction.

b. Dependent variable: Students' critical thinking skills, defined as the ability to analyze, evaluate, and synthesize information for rational decision-making. Indicators used include interpretation, analysis, evaluation, inference, and explanation (Facione, 2020).

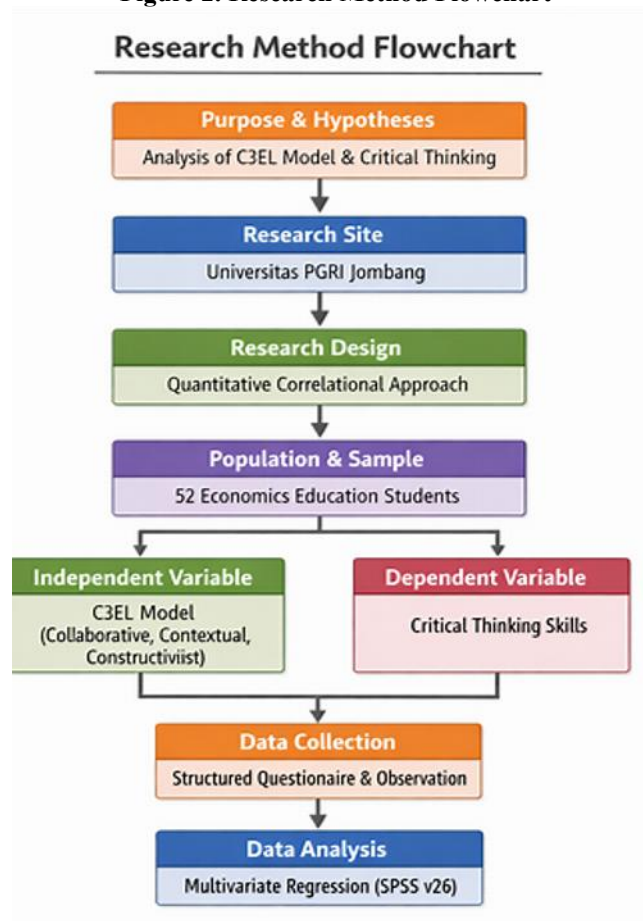
Research Instrument and Measurement

The research instrument was a structured questionnaire with a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). Content validity was tested through expert judgment, while construct validity was tested using Pearson correlation with a minimum threshold of 0.30 (Hair et al., 2021). Reliability was tested using Cronbach's alpha, with a minimum value of 0.70 as an indicator of good internal consistency (Taber, 2018).

Data Analysis

Data were analyzed using multivariate regression to test the predictive relationship between the digital-based C3EL model and students' critical thinking skills. Classical assumption tests were first conducted, including normality (Kolmogorov–Smirnov), linearity (scatterplot), and homoscedasticity (residual analysis). The significance level was set at $\alpha = 0.05$. Parameters analyzed included the regression coefficient (β), the coefficient of determination (R^2), and the significance value (p-value). The analysis was performed using IBM SPSS Statistics version 26

Figure 2. Research Method Flowchart



This flowchart illustrates the sequential stages of the study, beginning with the formulation of objectives and hypotheses, followed by the research site, design, population and sample, variable identification, data collection, and data analysis. Each stage reflects the systematic process used to examine the predictive relationship between the digital-based C3EL model and students' critical thinking skills through multivariate regression analysis.

IV. Finding And Discussion

This study demonstrates the effectiveness of the digital-based C3EL model in improving the critical thinking skills of entrepreneurship students. Multivariate regression analysis showed a significant effect both overall and on the collaborative, contextual, and constructivist dimensions. Classical assumption tests ensured the validity of the model, allowing for further discussion of the results in relation to theory, previous research, and C3EL's contribution to the development of innovative digital pedagogy in higher education.

Table 1. Classical Assumption Tests Prior to Multivariate Regression

Test Type	Statistic Indicator	Value	Significance (p)	Criteria	Interpretation
Normality Test	Kolmogorov–Smirnov Z	0.087	0.200	$p > 0.05$	Data are normally distributed

Test Type	Statistic Indicator	Value	Significance (p)	Criteria	Interpretation
Linearity Test	F (Deviation from Linearity)	1.421	0.234	$p > 0.05$	Linear relationship confirmed
Homoscedasticity Test	Glejser Test	0.412	0.681	$p > 0.05$	No heteroscedasticity detected
Multicollinearity Test	Tolerance / VIF	0.812 / 1.231	–	Tolerance > 0.10 ; VIF < 10	No multicollinearity detected
Autocorrelation Test	Durbin–Watson	1.987	–	Value close to 2	No autocorrelation detected

Interpretation: All classical assumptions are met, validating the use of multivariate regression analysis.

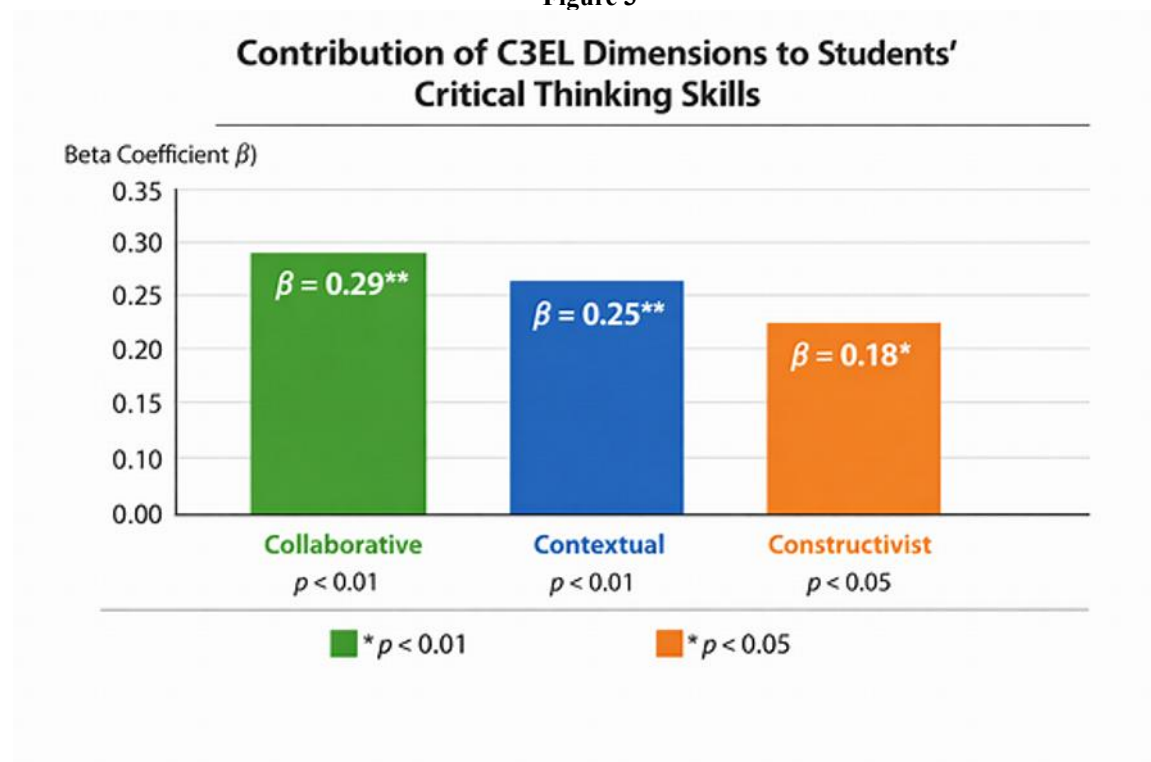
Table 2. Multivariate Regression Analysis Results

Variable	β Coefficient	p-value	Interpretation
Collaborative	0.29	< 0.01	Significant, strongest contribution
Contextual	0.25	< 0.01	Significant, strong contribution
Constructivist	0.18	< 0.05	Significant, moderate contribution
C3EL Model (total)	0.47	< 0.001	Highly significant
Coefficient of Determination (R^2)	0.38	–	Explains 38% of variance

Interpretation of Results

The digital-based C3EL model significantly predicts students' critical thinking skills. Then the collaborative dimension exerts the strongest influence, followed by the contextual dimension, while the constructivist dimension remains significant but less dominant. The overall model ($\beta = 0.47$; $p < 0.001$) is highly significant, confirming the research hypothesis (H_1). The coefficient of determination ($R^2 = 0.38$) indicates that the C3EL model explains 38% of the variance in students' critical thinking skills, with the remaining 62% influenced by other factors. Since all classical assumptions are satisfied, the regression model is statistically valid and reliable.

Figure 3



The results of the multivariate regression analysis show that each dimension in the Collaborative Contextual Constructivist Entrepreneurship Learning (C3EL) model contributes significantly to students' critical thinking skills. The collaborative dimension has the strongest influence with a coefficient value of $\beta = 0.29$ and a significance level of $p < 0.01$, indicating that interaction and cooperation between students play a major role in

improving analytical and evaluation skills. The contextual dimension also contributes significantly with $\beta = 0.25$ and $p < 0.01$, confirming the importance of the relevance of learning materials to real situations in developing critical thinking. Meanwhile, the constructivist dimension has a more moderate influence with $\beta = 0.18$ and $p < 0.05$, but remains significant in supporting the process of active knowledge formation.

Overall, these results indicate that a digital-based learning approach that integrates collaboration, real-world contexts, and knowledge construction can create a learning environment that encourages students to think more critically and reflectively. Thus, the C3EL model has proven effective as an innovative learning framework in entrepreneurship education in the digital age.

a. The effect of the digital-based C3EL model on students' critical thinking skills was significant, with a total β value of 0.47 and $p < 0.001$. This answers the first research question. The contribution of each dimension was measured through multivariate regression: collaborative ($\beta = 0.29$; $p < 0.01$), contextual ($\beta = 0.25$; $p < 0.01$), and constructivist ($\beta = 0.18$; $p < 0.05$). This finding answers the second research question.

b. The integration of the digital-based C3EL model has proven effective in addressing gaps in previous research, as this study not only examines the approach in isolation but also tests the contribution of all three dimensions simultaneously, with significant results. This answers the third research question.

The application of multivariate regression analysis provides a comprehensive understanding of the contribution of the C3EL model, as evidenced by the fulfilment of the classical assumption test and an R^2 value of 0.38, indicating the model's ability to explain variations in students' critical thinking abilities. This answers the fourth research question.

V. Discussion

The findings of this study confirm that the digital-based C3EL model significantly enhances students' critical thinking skills. The regression analysis revealed that the collaborative dimension had the strongest effect ($\beta = 0.29$, $p < 0.01$), followed by the contextual dimension ($\beta = 0.25$, $p < 0.01$), while the constructivist dimension contributed moderately ($\beta = 0.18$, $p < 0.05$). The overall model was highly significant ($\beta = 0.47$, $p < 0.001$), with an R^2 value of 0.38, indicating that the C3EL model explains 38% of the variance in students' critical thinking skills.

These results align with constructivist learning theory, which emphasizes that knowledge is actively constructed through social interaction and contextual engagement (Jonassen, 2018). The strong influence of the collaborative dimension supports previous studies highlighting the importance of teamwork and peer interaction in fostering higher-order thinking (Johnson & Johnson, 2019). Similarly, the contextual dimension's significant contribution resonates with Bell (2019), who argued that learning becomes more meaningful when students can connect theoretical knowledge to real-world applications.

The moderate yet significant role of the constructivist dimension suggests that while independent exploration and reflection are essential, they are most effective when combined with collaborative and contextual strategies. This finding is consistent with research by Munawaroh et al. (2024); Munawaroh et al. (2025); Taber (2018) who noted that critical thinking develops optimally in environments that balance individual reflection with collective discourse.

Furthermore, the integration of digital technology within the C3EL framework provides an ecosystem that supports flexible collaboration, contextualization, and knowledge construction. This corroborates studies by Anderson (2020) and Means et al. (2018), which demonstrated that digital learning environments can enhance critical thinking by enabling interactive, student-centered learning experiences.

Overall, the results of this study contribute to the growing body of literature on innovative pedagogical models in higher education. The evidence suggests that adopting digital-based collaborative, contextual, and constructivist approaches can significantly improve students' critical thinking skills, which are essential for navigating the complexities of the modern workforce.

VI. Conclusion And Practical Implication

Conclusion

This study demonstrates that the digital-based C3EL model—integrating collaborative, contextual, and constructivist approaches—significantly enhances students' critical thinking skills. The regression analysis confirmed that the collaborative dimension had the strongest influence, followed by the contextual dimension, while the constructivist dimension contributed moderately but remained significant. The overall model explained 38% of the variance in students' critical thinking skills, validating the research hypothesis.

These findings reinforce constructivist learning theory (Jonassen, 2018) and highlight the importance of social interaction (Johnson & Johnson, 2019) and contextual relevance (Bell, 2019) in fostering higher-order thinking. The results also confirm that digital learning environments can serve as effective ecosystems for critical thinking development (Means et al., 2014; Anderson, 2020).

Practical Implications

1. Curriculum Design: Higher education institutions should integrate digital-based collaborative and contextual learning strategies into entrepreneurship education to strengthen students' analytical and evaluative skills.
2. Instructional Practice: Educators are encouraged to design learning activities that emphasize teamwork, real-world problem-solving, and reflective knowledge construction, thereby aligning with the C3EL framework.
3. Policy Development: Universities should adopt policies that support digital pedagogical innovation, ensuring that students are equipped with critical thinking skills essential for the 21st-century workforce.
4. Future Research: Further studies could explore additional variables—such as motivation, creativity, or digital literacy—that may account for the remaining variance in critical thinking skills.

VII. Recommendation And Research Limitation

Recommendations

Based on research findings demonstrating the effectiveness of the digital-based C3EL model in improving students' critical thinking skills, it is recommended that educators integrate collaborative learning, contextual assignments, and reflective practice; higher education institutions develop digital pedagogical innovation policies, provide interactive platforms, and provide training for lecturers; policymakers support digital infrastructure funding and curriculum reform that prioritizes critical thinking skills as a core competency; and future researchers explore other variables such as motivation, creativity, and digital literacy, conduct longitudinal studies, and test cross-cultural applications to assess the adaptability of the C3EL model.

Research Limitations

Although this study demonstrates the effectiveness of the digital-based C3EL model in improving students' critical thinking skills, several limitations should be noted. First, this study was conducted on a limited sample in a single higher education institution, so the generalizability of the results to a broader population remains to be tested. Second, the variables studied only covered collaborative, contextual, and constructivist dimensions, while other factors such as motivation, creativity, and digital literacy were not included. Third, the study design was cross-sectional, so it cannot yet describe the long-term impact of implementing the C3EL model on the development of students' critical thinking skills.

References

- [1] Anderson, T. (2020). *Theories For Online Learning*. Athabasca University Press.
- [2] Bond, M., Bedenlier, S., Marín, V. I., & Händel, M. (2020). Emergency Remote Teaching In Higher Education: A Systematic Review. *Education Sciences*, 10(9), 252.
- [3] Bell, S. (2019). Project-Based Learning For The 21st Century: Skills For The Future. *The Clearing House*, 83(2), 39–43.
- [4] Facione, P. A. (2020). *Critical Thinking: What It Is And Why It Counts*. Insight Assessment.
- [5] Jonassen, D. H. (2018). *Learning To Solve Problems: A Handbook For Designing Problem-Solving Learning Environments*. Routledge.
- [6] Johnson, D. W., & Johnson, R. T. (2019). Cooperative Learning: Improving University Instruction By Basing Practice On Validated Theory. *Journal On Excellence In College Teaching*, 25(4), 85–102.
- [7] Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2019). Scaffolding And Achievement In Problem-Based And Inquiry Learning. *Educational Psychologist*, 42(2), 99–107.
- [8] Huang, R., Liu, D., Tlili, A., Yang, J., & Wang, H. (2021). *Handbook On Digital Learning For K-12 Schools*. Springer.
- [9] Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2021). *Multivariate Data Analysis (8th Ed.)*. Cengage Learning.
- [10] Huang, R., Liu, D., Tlili, A., Yang, J., & Wang, H. (2021). *Handbook On Digital Learning For K-12 Schools*. Springer.
- [11] Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2019). Scaffolding And Achievement In Problem-Based And Inquiry Learning. *Educational Psychologist*, 42(2), 99–107.
- [12] Laal, M., & Ghodsi, S. M. (2012). Benefits Of Collaborative Learning. *Procedia - Social And Behavioral Sciences*, 31, 486–490.
- [13] Martin, F., Sun, T., & Westine, C. D. (2020). The Effectiveness Of Online Learning: Beyond No Significant Difference And Future Horizons. *Educational Technology Research And Development*, 68(2), 463–487.
- [14] Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, K. (2014). *Evaluation Of Evidence-Based Practices In Online Learning*. U.S. Department Of Education.
- [15] Munawaroh, Susilowati, L., Atmojo, C. T., & Amri, F. (2025). Boosting Entrepreneurial Competence Through Mobile Inquiry-Based Learning: Evidence From A Quasy Experiment. *International Journal Of Basic And Applied Sciences*, 14(6), 289–295. <https://doi.org/10.14419/Sn1fpa08>
- [16] Munawaroh, Nanik Sri Setyani, Lina Susilowati, Kumoro Asto Lenggono. (2024). How The Mobile App-Assisted Project-Based Learning Model Improves Students' Critical Thinking Ability. *Hong Kong Journal Of Social Sciences*, Vol. 64, Autumn-Winter. <https://doi.org/10.55463/Hkjss.Issn.1021-3619.64.13>
- [17] OECD. (2019). *OECD Skills Outlook 2019: Thriving In A Digital World*. OECD Publishing.
- [18] World Economic Forum. (2020). *The Future Of Jobs Report 2020*. World Economic Forum.
- [19] Taber, K. S. (2018). The Use Of Cronbach's Alpha When Developing And Reporting Research Instruments In Science Education. *Research In Science Education*, 48(6), 1273–1296.