



Metacognitive Awareness: Fostering Cognitive Regulation through Hybrid Problem-Based Learning (HyProBeL) in Higher Education

Halimatus Sa'diyah

Sekolah Tinggi Agama Islam Cendekia Insani, Indonesia

DOI: <https://doi.org/10.61987/jsse.v4i3.3104>

Article History:

Received: 17 June 2026

Revised: 19 August 2026

Accepted: 02 October 2026

Keywords:

Metacognitive Awareness,
Hybrid Problem-Based
Learning, Higher Education,
Self-Regulated Learning

Abstract:

Metacognitive awareness is essential for university students to plan, monitor, evaluate, and regulate their learning processes. However, conventional problem-based learning (PBL) often provides limited opportunities for students to develop these metacognitive skills systematically across different learning environments. This study aims to evaluate HyProBeL, a five-phase learning model integrating asynchronous digital learning and synchronous face-to-face PBL, in enhancing students' metacognitive awareness. A quasi-experimental pretest-posttest non-equivalent control group design was employed with 72 undergraduate Educational Management students from two intact classes. Data were collected using an adapted Metacognitive Awareness Inventory and analyzed through ANCOVA and N-gain analysis using SPSS 26.0. The results revealed a significant adjusted post-test difference between the experimental and control groups ($F=83.908$, $p<.001$, partial $\eta^2=.549$). HyProBeL produced higher N-gain scores in Regulation of Cognition (.71, high) and Knowledge of Cognition (.58, moderate) than conventional PBL (.26 and .25, respectively). The findings suggest that effective integration of asynchronous and face-to-face activities should align with metacognitive demands. Higher education instructors are encouraged to design learning environments that emphasize structured planning, monitoring, argumentation, and reflection to promote deeper and sustainable learning outcomes.

INTRODUCTION

The rapid transformation of higher education through digital technologies, artificial intelligence, and expanding information environments has increased the need for students to (Dermawan & Yusuf, 2026; Hina & Solikhatin, 2025; Sholeh et al., 2025; Sumarni et al., 2026). Beyond acquiring disciplinary knowledge, university students are expected to identify learning difficulties, select appropriate strategies, monitor their understanding, and evaluate the effectiveness of their learning processes (Al-Sultan et al., 2024; Grosman et al., 2024; Tian, 2024; Asyari et al., 2025). These abilities are especially important when students encounter complex, open-ended problems for which they cannot obtain solutions by directly applying previously learned procedures. In this context, metacognitive awareness is an important learning capacity because it enables students to regulate their cognitive processes and make informed decisions throughout learning (Fergus, 2022; Salehomoum, 2023; Arifin et al., 2025; Suratman & Sugiyono, 2025).

*Corresponding Author:

Halimatus Sa'diyah, Sekolah Tinggi Agama Islam Cendekia Insani, Indonesia

Email: thusy723@gmail.com

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environments can be deliberately sequenced according to the metacognitive demands of different stages of problem solving (Anisaturrizqi et al., 2025; Mhlanga, 2024). This gap is important because simply combining online and face-to-face instruction does not necessarily ensure that students receive structured opportunities to plan, monitor, and evaluate their cognition.

To address this gap, the present study employs Hybrid Problem-Based Learning (HyProBeL). This structured instructional configuration assigns different pedagogical and metacognitive functions to asynchronous and face-to-face learning environments. The model begins with asynchronous problem orientation and instructional planning, allowing students to analyze ill-structured problems, identify prior and missing knowledge, establish learning goals, and organize inquiry activities. Investigation subsequently combines individual online exploration with face-to-face group examination, followed by classroom-based development and defense of learning artifacts. The learning cycle concludes with asynchronous metacognitive reflection in which students evaluate their problem-solving processes. Thus, HyProBeL does not claim to represent an entirely new form of blended PBL; rather, it operationalizes a deliberate alignment between hybrid learning environments, problem-based inquiry, and the metacognitive processes of planning, monitoring, and evaluation.

Accordingly, this study aims to examine HyPro empiricallyBeL's effectiveness in fostering students' metacognitive awareness in higher education. By quantitatively examining changes in students' metacognitive awareness after implementing the model, the study seeks to provide empirical evidence on whether the structured sequencing of asynchronous and face-to-face learning activities can strengthen students' capacity to regulate their cognition during problem-based learning. The findings are expected to contribute to evidence-based instructional designs that integrate hybrid learning with metacognitive regulation rather than treating digital learning as merely an additional delivery channel.

RESEARCH METHODS

This study used a quantitative, quasi-experimental pretest-posttest non-equivalent control group design to examine the effect of Hybrid Problem-Based Learning (HyProBeL) on students' metacognitive awareness (Panggabean et al., 2021). Two intact fourth-semester classes comprising 72 undergraduate students participated in the study. The experimental group received HyProBeL, while the control group received conventional face-to-face Problem-Based Learning (PBL). Both groups completed metacognitive awareness pre-tests before the intervention and post-tests after the intervention. The pre-test scores were then used as a covariate in the ANCOVA to adjust for initial differences between the non-equivalent groups statistically. Table 1 presents the research design and group allocation.

Table 1. Research Design and Group Allocation				
Group	n	Pre-test	Treatment	Post-test
Experimental	37	Metacognitive Awareness	HyProBeL	Metacognitive Awareness
Control	35	Metacognitive Awareness	Conventional Face-to-Face PBL	Metacognitive Awareness

The participants were undergraduate students enrolled in the Educational Management Study Program at a public university in Indonesia. The study used purposive

cluster sampling because it drew on pre-existing classes and individual randomization was not feasible in the institutional setting. All eligible students in the two selected classes were included, and participants were aged 19–21 years. A preliminary comparison of cumulative Grade Point Average (GPA) showed no statistically significant difference between the two groups before the intervention, indicating comparable baseline academic performance. The experimental group followed the five-phase HyProBeL model, integrating asynchronous online activities with synchronous face-to-face problem-based learning. The model organized problem orientation and planning through asynchronous activities, combined individual online investigation with face-to-face collaborative inquiry, conducted solution development and presentation in the classroom, and concluded with structured asynchronous reflection. The control group followed conventional face-to-face PBL involving problem orientation, investigation, discussion, solution development, presentation, and evaluation within scheduled classroom sessions.

We measured students' metacognitive awareness using an adapted version of the Metacognitive Awareness Inventory (MAI) (Chang et al., 2021). We contextualized the instrument for the higher-education problem-based learning setting and assessed metacognitive awareness through knowledge and regulation of cognition, particularly planning, monitoring, and evaluation. We examined internal consistency using Cronbach's alpha based on responses from all 72 participants. The resulting reliability coefficient was $\alpha = .87$, indicating good internal consistency. We collected data in three stages: administering the pre-test, implementing the respective instructional treatments, and administering the post-test. We applied the same measurement procedure to both groups to maintain consistency across the experimental and control conditions.

We conducted an a priori power analysis using GPower for the planned ANCOVA (Peng et al., 2024). The analysis was specified for two groups with one covariate, an alpha level of .05, statistical power of .80, and a medium anticipated effect size ($f = .25$), resulting in an estimated required sample of approximately 128 participants. However, only 72 eligible students were available within the two intact classes. We therefore retained the complete accessible cohort without altering the existing class structure. We considered this sample-size limitation when interpreting the inferential findings. We reported the observed effect size and 95% confidence interval alongside statistical significance to describe the magnitude and precision of the treatment effect.

We analyzed the data using descriptive statistics and Analysis of Covariance (ANCOVA) (Chara et al., 2022). Post-test metacognitive awareness was the dependent variable, instructional group the independent variable, and pre-test metacognitive awareness the covariate. Before conducting ANCOVA, we examined the analysis assumptions. We assessed normality using the Shapiro–Wilk test and visual inspection of Q–Q plots; homogeneity of variance using Levene's test; and linearity by examining the relationship between pre-test and post-test metacognitive awareness scores. We examined homogeneity of regression slopes through the interaction between treatment group and the pre-test covariate; a non-significant interaction supported comparable regression relationships across groups. We then used ANCOVA to compare adjusted post-test metacognitive awareness between the two instructional groups. We evaluated statistical significance at $\alpha = .05$ and reported effect sizes and 95% confidence intervals alongside the ANCOVA results.

RESULTS AND DISCUSSION

Results

The results examine three interconnected aspects of students' metacognitive development following the instructional intervention. First, baseline descriptive statistics establish the initial comparability of the two groups. Second, ANCOVA determines whether the instructional treatment produced significant differences in overall metacognitive awareness. Third, normalized gain analysis identifies differences in Knowledge of Cognition and Regulation of Cognition between instructional conditions.

Comparable Baseline Metacognitive Awareness between the Groups

Before the instructional intervention, we administered a pre-test to both groups to establish baseline metacognitive awareness. The analysis focused on two dimensions of metacognitive awareness: Knowledge of Cognition and Regulation of Cognition, together with the overall metacognitive awareness score. We calculated descriptive statistics, including the minimum, maximum, mean, and standard deviation, for the 37 students in the HyProBeL group and the 35 students in the conventional PBL group. Table 2 presents the results.

Table 2. Pre-Test Descriptive Statistics of Students' Metacognitive Awareness

Dimension	Group	N	Min	Max	M	SD
Knowledge of Cognition	HyProBeL	37	48.00	76.00	62.43	6.82
	Conventional PBL	35	50.00	74.00	61.85	6.45
Regulation of Cognition	HyProBeL	37	52.00	78.00	64.11	7.15
	Conventional PBL	35	50.00	76.00	63.54	6.98
Total	HyProBeL	37	50.00	77.00	63.27	6.99
Metacognitive Awareness	Conventional PBL	35	50.00	75.00	62.70	6.72

As shown in Table 2, the two groups demonstrated relatively comparable levels of metacognitive awareness before the intervention. For Knowledge of Cognition, the HyProBeL group recorded a mean score of 62.43 (SD = 6.82), compared with 61.85 (SD = 6.45) in the conventional PBL group. A similar pattern was observed for Regulation of Cognition, with mean scores of 64.11 (SD = 7.15) and 63.54 (SD = 6.98), respectively. Overall metacognitive awareness scores were also similar, with a mean of 63.27 (SD = 6.99) for the HyProBeL group and 62.70 (SD = 6.72) for the conventional PBL group. These descriptive patterns indicate that the groups entered the intervention with broadly similar metacognitive profiles, reducing concerns that subsequent differences resulted from substantial baseline disparities.

This baseline comparability is particularly relevant because the study used intact classes rather than individual randomization. Although descriptive similarity cannot eliminate all possible pre-existing differences between the groups, the relatively close pre-test means provide an appropriate basis for subsequent covariate adjustment. The pre-test scores were therefore incorporated into the ANCOVA to statistically account for individual differences in initial metacognitive awareness when comparing post-test outcomes.

HyProBeL Produced a Significant Overall Improvement in Metacognitive Awareness

To determine whether the instructional treatment was associated with differences in students' post-test metacognitive awareness after accounting for their initial scores, an Analysis of Covariance (ANCOVA) was conducted. Pre-test metacognitive

awareness was entered as the covariate, instructional treatment as the fixed factor, and post-test metacognitive awareness as the dependent variable. The analysis showed a statistically significant effect of pedagogical treatment on students' adjusted post-test metacognitive awareness, $F(1, 69) = 83.908$, $p < .001$, partial $\eta^2 = .549$. Table 3 summarizes the ANCOVA results.

Table 3. ANCOVA Results for Post-Test Metacognitive Awareness

Source	Type III Sum of Squares	df	Mean Square	F	p	Partial η^2
Corrected Model	2485.420	2	1242.710	48.652	< .001	.585
Intercept	18420.150	1	18420.150	721.156	< .001	.913
Pre-Test (Covariate)	342.180	1	342.180	13.396	< .001	.163
Pedagogical Treatment	2143.240	1	2143.240	83.908	< .001	.549
Error	1762.450	69	25.543	-	-	-
Corrected Total	4247.870	71	-	-	-	-

The ANCOVA results indicate that pedagogical treatment was significantly associated with differences in post-test metacognitive awareness after controlling for pre-test scores. The treatment effect was substantial, with a partial eta squared of .549, indicating that the pedagogical treatment accounted for a large proportion of the adjusted variance in students' post-test metacognitive awareness. The pre-test covariate was also statistically significant, $F(1, 69) = 13.396$, $p < .001$, partial $\eta^2 = .163$, confirming that students' initial metacognitive awareness remained meaningfully related to their post-intervention scores.

The magnitude of the treatment effect provides stronger evidence than statistical significance alone. Given the quasi-experimental design, however, interpret the finding as evidence of a strong adjusted group difference rather than definitive proof of an exclusively causal effect of HyProBeL. Using intact classes means unobserved differences between groups cannot be completely ruled out. Nevertheless, after statistically accounting for baseline metacognitive awareness, the substantially stronger adjusted outcome associated with the HyProBeL condition suggests that the hybrid problem-based learning configuration was more effective within this study context than conventional face-to-face PBL.

The finding can be understood through the instructional structure of HyProBeL. Rather than merely combining online and face-to-face instruction, the model assigns different learning functions to each environment. Asynchronous activities give students opportunities to access problems, search for information, organize ideas, and prepare initial responses without the time constraints of classroom interaction. Face-to-face sessions subsequently support collaborative investigation, discussion, solution development, presentation, and immediate feedback. This functional distribution may create more continuous opportunities for students to regulate their learning while engaging with complex problems.

From a Cognitive Load Theory perspective, this arrangement may help students allocate cognitive resources toward task-relevant processing by distributing demanding activities across different learning environments. More importantly, the instructional sequence repeatedly requires students to decide what they know, what they need to investigate, how to proceed, and whether their emerging solutions are adequate. Thus, the statistical advantage observed for HyProBeL is theoretically consistent with a learning environment that makes metacognitive regulation an integral part of problem solving rather than an additional instructional component.

Regulation of Cognition Demonstrated the Strongest Gain under HyProBeL

To further identify which components of metacognitive awareness contributed to the overall improvement, we examined changes in Knowledge of Cognition and Regulation of Cognition separately using normalized gain scores. The analysis compared the mean pre-test and post-test scores and calculated the normalized gain (g) for each dimension and instructional group. Table 4 presents the results.

Table 4. Pre-Test, Post-Test, Mean Gain, Normalized Gain of Metacognitive Dimensions

Dimension	Group	Pre-Test (M)	Post-Test (M)	Mean Gain	N-Gain (g)	Interpretation
Knowledge of Cognition	HyProBeL	65.43	84.15	21.72	0.58	Moderate
	Conventional PBL	61.85	71.30	9.45	0.25	Low
Regulation of Cognition	HyProBeL	64.11	89.62	25.51	0.71	High
	Conventional PBL	63.54	73.12	9.58	0.26	Low

Table 4 shows a clear difference in improvement magnitude between the two instructional conditions. In the HyProBeL group, Knowledge of Cognition increased from a mean of 65.43 to 84.15, producing a mean gain of 21.72 and an N-gain of .58, categorized as moderate. Regulation of Cognition demonstrated a stronger increase, rising from 64.11 to 89.62, with a mean gain of 25.51 and an N-gain of .71, categorized as high. By comparison, the conventional PBL group demonstrated substantially smaller improvements. Knowledge of Cognition increased by 9.45 points (N-gain = .25), while Regulation of Cognition increased by 9.58 points (N-gain = .26), with both dimensions remaining within the low-gain category. The dimensional pattern suggests that the greatest improvement under HyProBeL occurred in Regulation of Cognition. The N-gain of .71 was higher than the .58 observed for Knowledge of Cognition, indicating that students exposed to HyProBeL experienced particularly substantial development in processes associated with planning, monitoring, evaluating, and modifying their learning activities. This pattern is consistent with the model's design, in which students repeatedly encounter tasks that require them to set learning goals, organize investigative strategies, monitor progress, evaluate emerging solutions, and reflect on the effectiveness of their problem-solving processes.

The stronger development of Regulation of Cognition can also be interpreted through the executive-control function of metacognition. Regulation involves an iterative process in which learners establish goals, select strategies, monitor performance, evaluate outcomes, and modify subsequent actions. The five-phase HyProBeL sequence provides repeated opportunities for this cycle. Problem orientation initiates goal setting; instructional planning requires students to organize their learning strategies; individual and collaborative investigation requires ongoing monitoring; solution development and presentation require evaluation and justification; and structured reflection provides an opportunity to reconsider the learning process's effectiveness. In contrast, Knowledge of Cognition concerns students' awareness of their own cognitive processes, strategies, and the conditions under which those strategies are appropriate. Such knowledge may require more sustained conceptual development than the immediate enactment of regulatory behaviors. Students may therefore become better able to regulate their learning through repeated practice before they develop equally strong explicit knowledge about cognition. The moderate N-gain for Knowledge of Cognition (.58), alongside the high N-gain for Regulation of Cognition (.71), supports this distinction.

The finding also differentiates HyProBeL from a conventional face-to-face PBL configuration. Both approaches expose students to problems and collaborative investigation, but HyProBeL deliberately distributes activities across asynchronous and face-to-face environments according to their learning functions. The asynchronous components provide additional space for individual preparation, information searching, planning, and reflection, while face-to-face activities emphasize interaction, cross-examination, feedback, and solution development. Consequently, the hybrid configuration may provide more frequent and varied occasions for students to exercise metacognitive regulation throughout the problem-solving process. Nevertheless, the dimensional findings should be interpreted as evidence of differential improvement rather than direct evidence of the mechanisms responsible for that improvement. The present study did not independently measure cognitive load, executive-control processes, or students' actual regulatory behaviors during learning. Therefore, the stronger Regulation of Cognition gain cannot be attributed exclusively to a particular cognitive mechanism. Future studies could strengthen this explanation by combining MAI scores with behavioral process data, reflective journals, learning analytics, classroom observations, or performance-based measures of metacognitive regulation.

Discussion

The findings demonstrate that HyProBeL was associated with substantially greater improvements in students' metacognitive awareness than conventional face-to-face PBL. The ANCOVA revealed a significant treatment effect after accounting for pre-test metacognitive awareness, with a large partial eta squared of .549. This finding suggests that the difference between the two instructional conditions was not merely reflected in raw post-test scores but remained substantial after statistically controlling for baseline metacognitive awareness. This result matters because both instructional approaches were problem-based, so the observed difference cannot be attributed solely to exposure to problem-solving activities. Rather, the distinctive organization of HyProBeL appears to have created a learning environment in which metacognitive processes were more consistently activated across different stages of learning (Rivas et al., 2022; Yakubu et al., 2025).

HyProBeL's stronger performance can be explained by how the model distributes cognitive and learning activities across asynchronous and face-to-face environments. Conventional PBL generally concentrates problem orientation, investigation, discussion, presentation, and evaluation within classroom interaction (Benlaghrissi et al., 2024; Hosna et al., 2025). Although such activities can stimulate metacognition, students may have limited opportunities to prepare individually before discussion or to revisit their reasoning after classroom activities. HyProBeL expands these opportunities by assigning specific learning functions to different environments. Asynchronous activities give students time to access problems, search for information, organize preliminary ideas, and reflect on their learning. At the same time, face-to-face sessions support collaborative inquiry, cross-examination, immediate feedback, and solution development (Widiasari et al., 2024; Zamroni et al., 2025). The hybrid model therefore contributes not simply by adding online learning to PBL, but by sequencing learning environments around different cognitive and metacognitive demands.

This interpretation aligns with Cognitive Load Theory, particularly the principle that instructional design should help learners allocate limited cognitive resources to learning-relevant processes (Aldhafeeri et al., 2023; Shaughnessy et al., 2022). In

HyProBeL, students do not have to perform every learning activity under the same temporal and interactional conditions. Asynchronous environments provide greater flexibility for individual information processing and preparation, whereas synchronous classroom activities concentrate on social interaction and collaborative problem solving. Such functional differentiation may reduce unnecessary pressure associated with simultaneously processing information, participating in discussion, and formulating solutions (Kumar et al., 2022). This does not mean the hybrid format automatically reduces cognitive load; rather, deliberately sequencing activities may create more favorable conditions for students to devote cognitive resources to planning, monitoring, evaluating, and revising their learning strategies.

The dimensional results provide a more specific explanation of this improvement. Regulation of Cognition demonstrated a high N-gain of .71 in the HyProBeL group, compared with .58 for Knowledge of Cognition. The difference is theoretically meaningful because Regulation of Cognition concerns the active management of learning through planning, monitoring, strategy selection, evaluation, and adjustment. Students enact these processes directly during problem-based inquiry (Wang et al., 2022). Students must determine what information they need, decide how to investigate the problem, monitor whether their evidence is sufficient, evaluate competing explanations, and modify their solutions when they identify weaknesses. HyProBeL repeatedly embeds these activities within its instructional sequence, making regulation a functional requirement of participation rather than an abstract concept that students encounter separately from the learning task (Sherratt et al., 2021).

The stronger gain in Regulation of Cognition can be explained through the executive-control dimension of metacognition, which involves setting goals, selecting strategies, monitoring progress, evaluating outcomes, and modifying actions (Gómez et al., 2024). The five-phase HyProBeL sequence closely supports this cycle: problem orientation establishes direction, planning organizes approaches, investigation requires monitoring, solution development and presentation promote evaluation, while reflection encourages strategic reconsideration. Repeated engagement in these processes may explain why Regulation of Cognition improved more than Knowledge of Cognition (Wang et al., 2022). Nevertheless, the moderate gain in Knowledge of Cognition remains meaningful, as students need time to conceptualize strategies, their purposes, and appropriate conditions. Thus, regulatory competencies may develop faster through repeated task-based practice.

The findings also provide a basis for distinguishing HyProBeL from conventional conceptions of blended learning. A hybrid learning model is not necessarily more effective simply because it uses two delivery modes (Retherford et al., 2021; Zhang, 2023). Its potential depends on whether each environment performs a meaningful pedagogical function. In the present study, online activities supported preparation, individual investigation, organization of ideas, and reflection, whereas face-to-face activities emphasized interaction, collaborative inquiry, feedback, presentation, and evaluation. This functional arrangement explains the observed outcomes more precisely than the general claim that technology improves learning. HyProBeL's contribution therefore lies in the pedagogical alignment among the learning environment, problem-solving activity, and metacognitive function.

These findings have implications for instructional design and learner development. HyProBeL suggests that metacognitive awareness can be strengthened when students repeatedly engage in planning, monitoring, evaluation, and reflection in

authentic problem-solving activities. Its hybrid structure provides lecturers with opportunities to embed metacognitive regulation across asynchronous preparation, collaborative inquiry, solution development, and reflection. However, interpret the findings cautiously because the study involved 72 students from two intact classes within one Educational Management program. The quasi-experimental design cannot fully rule out pre-existing differences, and the self-report MAI may not capture actual metacognitive behavior. Future research should use larger samples, stronger designs, and multimethod assessment.

Overall, the study contributes empirical evidence that the pedagogical value of hybrid problem-based learning may depend less on simply combining online and face-to-face instruction than on aligning learning environments with metacognitive demands. The particularly great improvement in Regulation of Cognition suggests that repeated opportunities to plan, monitor, evaluate, and revise learning actions may be a central feature of effective metacognitive instruction. HyProBeL consequently provides a structured approach for integrating metacognitive regulation into problem-based higher education while retaining the collaborative and authentic characteristics of PBL. However, its broader effectiveness requires further examination across larger populations, disciplinary contexts, and measurement approaches.

CONCLUSION

This study demonstrates that HyProBeL was associated with greater improvements in students' metacognitive awareness than conventional face-to-face PBL, with particularly pronounced gains in Regulation of Cognition. The findings contribute to metacognition and problem-based learning scholarship by demonstrating the value of functionally aligning asynchronous and face-to-face environments with planning, monitoring, evaluation, and reflection. The study also implies that hybrid learning should be designed around cognitive functions rather than technology integration alone. However, the quasi-experimental design, limited sample, single institutional context, and self-report measure constrain generalizability. Future research should employ larger multi-site samples, stronger designs, and multimethod assessment.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the university, participating lecturers, and students who supported this study. Their cooperation, engagement, and contributions to instructional activities and data collection were essential to completing the research and developing the findings presented in this article.

CONFLICTS OF INTEREST

No conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

Generative AI was employed exclusively for linguistic refinement and readability improvements. All outputs were carefully verified and edited by the authors, who retain full accountability for the content of this manuscript

REFERENCES

- Akmansyah, M., Putri, I. A., Nurnazli, N., & Mujahid, A. (2026). Beyond Teacher Competence: Uncovering the Key Determinants of Student Learning and Achievement of Islamic Religious Education Subjects. *Indonesian Journal of Education and Social Studies*, 5(1), 119–133. <https://doi.org/10.33650/ijess.v5i1.13146>
- Aldhafeeri, F. M., & Alotaibi, A. A. (2023). Reimagining Education for Successful and Sustainable Digital Shifting. *SAGE Open*, 13(1), 1–20. <https://doi.org/10.1177/21582440231154474>
- Al-Sultan, M. S. A., & Daif-Allah, A. S. (2024). The Effect of Using the Role-Play Strategic Approach on the Vocabulary Development of the Beginner Level Learners at Qassim University. *Dirasat: Human and Social Sciences*, 51(3), 481–498. <https://doi.org/10.35516/hum.v51i3.3581>
- Anisaturrizqi, R., & Yulianti, R. R. (2025). Global Trends and Transformative Insights in Artificial Intelligence (AI) Research : A Bibliometric Analysis of the Dynamics of Education, Ethics, and Innovation. *Indonesian Journal of Progressive Pedagogy*, 01(01), 34–48. <https://doi.org/10.61987/ijpp.v1i1.665>
- Arici, N. Ü., & Simsek, Ü. (2023). The Effect of Augmented Reality Applications Integrated with Modeling on Pre-Service Science Teachers' Modeling Skills and Academic Achievements. *Journal of Science Learning*, 6(4), 387–400. <https://doi.org/10.17509/jsl.v6i4.60780>
- Arifin, M., Jazilurrahman, J., & AS, A. H. (2025). Continuous Improvement in Learning Innovation Management to Enhance Students' Learning Motivation. *Business and Applied Management Journal*, 3(1), 168–182. <https://doi.org/10.61987/bamj.v3i1.1302>
- Asyari, A., Hamami, T., & Sukiman, S. (2025). The Role of Digital Applications in Enhancing Qur'an Memorization Learning. *Indonesian Journal of Progressive Pedagogy*, 1(2), 116–127. <https://doi.org/10.61987/ijpp.v1i2.1265>
- Benlaghrissi, H., & Ouahidi, L. M. (2024). The Impact of Mobile-Assisted Project-Based Learning on Developing EFL Students' Speaking Skills. *Smart Learning Environments*, 11(1). <https://doi.org/10.1186/s40561-024-00303-y>
- Chang, C., Colón-Berlinger, M., Parker, C., & Solomon, D. (2021). Medical Student Progress Examination Performance and Its Relationship With Metacognition, Critical Thinking, and Self-Regulated Learning Strategies. *Academic Medicine*, 96(2), 278–284. <https://doi.org/10.1097/ACM.0000000000003766>
- Chara, R. (2022). School-community Collaboration in Inquiry-based Learning to Strengthen Religious Character and Improve Learning Outcomes of Students. *International Journal of Instruction*, 15(3), 913–930. <https://doi.org/10.29333/iji.2022.15349a>
- Daguay-James, H., & Bulusan, F. (2020). Metacognitive Strategies on Reading English Texts of ESL Freshmen: A Sequential Explanatory Mixed Design. *TESOL International Journal*, 15(1), 20–30.
- Dermawan, O., & Yusuf, T. K. (2026). Toward Holistic Curriculum Management in Islamic Early Childhood Education: A Framework for Integrated Learning Development. *Early Childhood Development Gazette*, 3(1), 11–22. <https://doi.org/10.61987/gazette.v3i1.1789>

- Exintaris, B., Karunaratne, N., & Yuriev, E. (2023). Metacognition and Critical Thinking: Using ChatGPT-Generated Responses as Prompts for Critique in a Problem-Solving Workshop (SMARTCHEMPer). *Journal of Chemical Education*, 100(8), 2972–2980. <https://doi.org/10.1021/acs.jchemed.3c00481>
- Fadere, A. O., Akinnubi, O. P., & Ogbaini, C. A. (2024). Transforming Learning: The Role of School-Related Factors in Student Achievement. *Indonesian Journal of Education and Social Studies*, 3(1), 12–22. <https://doi.org/10.33650/ijess.v3i1.8170>
- Fadliah, H., & Putri, R. M. (2026). Smartphone Use and Students' Learning Concentration: Examining the Impact of Digital Distraction. *Journal of Social Studies and Education*, 4(1), 102–113. <https://doi.org/10.61987/jsse.v4i1.3004>
- Fergus, S. (2022). Are Undergraduate Students Studying Smart? Insights into Study Strategies and Habits Across a Program of Study. *Journal of University Teaching and Learning Practice*, 19(2). <https://doi.org/10.53761/1.19.2.8>
- Gómez Murcia, J. J. (2024). Socioemotional Frontiers of AI: Influence of Connections 6.0. *European Public and Social Innovation Review*, 9. <https://doi.org/10.31637/epsir-2024-1144>
- Grosman, H. E., Aragon-Guevara, D., McQuaid, G. A., Wallace, G. L., & Lee, N. R. (2024). Academic Learning Challenges and Links to Vocational Outcomes in Young Autistic Adults. *Autism*. <https://doi.org/10.1177/13623613241255774>
- Hamidah, L. R., & Maspupah, M. (2026). The Impact of Pedagogical Deep Learning on Critical Thinking in Middle School Science. *Journal of Social Studies and Education*, 4(2), 193–205. <https://doi.org/10.61987/jsse.v4i2.3029>
- Hayati, F., Sutisna, M., Rumiati, S., Pujiastuti, S. R., & Subkhan, M. (2026). Developing Video-Based Image Media with Problem-Based Learning to Enhance Learning Outcomes on Pancasila History and Patriotic Attitudes. *Journal of Social Studies and Education*, 4(2), 234–249. <https://doi.org/10.61987/jsse.v4i2.3037>
- Hina, S., & Solikhatin, S. (2025). Forming a Caring Generation: Integration of Environmental Ethics in Fish Cultivation Learning for Early Childhood. *Journal of Psychological Insight*, 1(2), 119–129. <https://doi.org/10.61987/jpi.v1i2.781>
- Hosna, R., Baharun, H., Hery Qusyairi, L. A., Mualimin, M., Fauzi, A., & Putri, D. F. (2025). Utilization of Digital Advertising Strategy in Marketing Educational Programs. *2025 11th International Conference on Education and Technology (ICET)*, 34–39. <https://doi.org/10.1109/icet67257.2025.11290729>
- Ilmi, K. (2024). Interpersonal Communication of Madrasah Heads in Increasing Teacher Work Motivation. *Business and Applied Management Journal*, 1(2), 104–117. <https://doi.org/10.61987/bamj.v1i2.480>
- Islamiyah, M. (2025). A Digital Transformation Framework for Pesantren: Integrating Technology and Sharia Principles in Startup Development. *Al-Fiqh Journal of Contemporary Islamic Law*, 1(2), 77–87. <https://doi.org/10.61987/fiqh.v1i2.1354>
- Jang, E., Seo, Y. S., & Brutt-Griffler, J. (2023). Building Academic Resilience in Literacy: Digital Reading Practices and Motivational and Cognitive Engagement. *Reading Research Quarterly*, 58(1), 160–176. <https://doi.org/10.1002/rrq.486>
- Kumar, V. S., Pareek, P. K., De Albuquerque, V. H. C., Khanna, A., Gupta, D., & Madhumala, R. B. (2022). Multimodal Sentiment Analysis using Kernel-Based Support Vector Machine. In *2nd IEEE International Conference on Advanced Technologies in Intelligent Control, Environment, Computing and Communication Engineering, ICATIECE 2022*. <https://doi.org/10.1109/ICATIECE56365.2022.10046818>

- Mhlanga, D. (2024). Digital Transformation of Education: The Limitations and Prospects of Introducing the Fourth Industrial Revolution Asynchronous Online Learning in Emerging Markets. In *Discover Education* (Vol. 3, Issue 1). <https://doi.org/10.1007/s44217-024-00115-9>
- Panggabean, J. H., Defi Siregar, M. S., & Rajagukguk, J. (2021). The Effect of Teams Games Tournament (TGT) Method on Learning Outcomes and Conceptual Knowledge in Physics Science. In *Journal of Physics: Conference Series* (Vol. 1819, Issue 1). <https://doi.org/10.1088/1742-6596/1819/1/012047>
- Peng, X., Hou, W. P., Ding, Y. S., Wang, Q., Li, F., Sha, S., Yu, C. C., Zhang, X. J., Zhou, F. C., & Wang, C. Y. (2024). Independent Effects of Early Life Adversity on Social Cognitive Function in Patients with Schizophrenia. *Frontiers in Psychiatry*, 15. <https://doi.org/10.3389/fpsy.2024.1343188>
- Rasimah, E., Pudjiastuti, S. R., Sutisna, M., Rumiati, S., & Subkhan, M. (2026). Visualizing Civic Values: Integrating Canva Poster Design and Project-Based Learning to Foster National Identity and Student Patriotism. *Journal of Social Studies and Education*, 4(2), 261–275. <https://doi.org/10.61987/jsse.v4i2.3042>
- Razkane, H., Sayeh, A. Y., Diouny, S., & Yeou, M. (2023). Eleventh-grade Students' Use of Metacognitive Reading Strategies in Arabic (L1) and English (L3). *International Journal of Instruction*, 16(1), 573–588. <https://doi.org/10.29333/iji.2023.16132a>
- Rehan, A. (2025). The Existence of Cryptocurrency from the Perspective of Islamic Fiqh: A Legal Analysis of the Buying and Selling of Digital Assets. *Al-Fiqh: Journal of Contemporary Islamic Law*, 1(1), 1–10. <https://doi.org/10.61987/fiqh.v1i1.802>
- Retherford, J., Wyckoff, K. N., & Mobley, S. J. (2021). Lessons Learned in a Mixed-mode Teaching Experience. In *ASEE Annual Conference and Exposition, Conference Proceedings*. <https://doi.org/10.18260/1-2--37443>
- Rivas, S. F., Saiz, C., & Ossa, C. (2022). Metacognitive Strategies and Development of Critical Thinking in Higher Education. *Frontiers in Psychology*, 13. <https://doi.org/10.3389/fpsyg.2022.913219>
- Salehomoum, M. (2023). Think-Aloud: Effect on Adolescent Deaf Students' Use of Reading Comprehension Strategies. *Journal of Deaf Studies and Deaf Education*, 28(1), 99–114. <https://doi.org/10.1093/deafed/enac037>
- Shaughnessy, A. F., & Erlich, D. R. (2022). The Science of Education: Using Learning Theory to Solve Teaching Problems in Medical Education. *Education for Primary Care*, 33(4), 194–198. <https://doi.org/10.1080/14739879.2022.2053344>
- Sherratt, F., Plummer, A., & Iravani, P. (2021). Understanding LSTM Network Behavior of IMU-based Locomotion Mode Recognition for Applications in Prostheses and Wearables. *Sensors (Switzerland)*, 21(4), 1–23. <https://doi.org/10.3390/s21041264>
- Sholeh, W., Sholihah, atun, & Vahlevi, S. (2025). Business and Applied Management Journal School Management Strategies for Implementing Deep Learning in Indonesian Junior High Schools. *Business and Applied Management Journal*, 03(01), 63–74. <https://doi.org/10.61987/bamj.v3i1.800>
- Sumarni, M., Maspupah, M., & Hartati, S. (2026). Integrating Interactive Game-Based Learning into PBL: Effects on Students' Analytical Thinking and Engagement. *Journal of Social Studies and Education*, 4(2), 206–218. <https://doi.org/10.61987/jsse.v4i2.3027>

- Suratman, & Sugiyono. (2025). The Mediating Role of Teachers' Digital Competence in the Relationship Between Curriculum Management and Smart Learning. *Business and Applied Management Journal*, 3(2), 315–326. <https://doi.org/10.61987/bamj.v3i2.1646>
- Suro, L. A., & Anggraeni, A. F. D. G. (2024). Targeting Educational Quality: The Role of Educator Management Transformation in Enhancing Services. *Business and Applied Management Journal*, 2(1), 25–37. <https://doi.org/10.61987/bamj.v2i1.543>
- Tanti., Anwar, K., Jamaluddin., Saleh, A. S., Yusup, D. K., & Jahanifar, M. (2025). Faith Meets Technology: Navigating Student Satisfaction in Indonesia'S Islamic Higher Education Online Learning. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, 9(2), 695–708. <https://doi.org/10.22437/jiituj.v9i2.41513>
- Teng, M. F., & Yue, M. (2023). Metacognitive Writing Strategies, Critical Thinking Skills, and Academic Writing Performance: A Structural Equation Modeling Approach. *Metacognition and Learning*, 18(1), 237–260. <https://doi.org/10.1007/s11409-022-09328-5>
- Tian, Y. (2024). Empowering College Physical Education: AI-Driven Training, Teaching, and Intelligent Information Processing. *MCB Molecular and Cellular Biomechanics*, 21(1). <https://doi.org/10.62617/mcb.v21i1.327>
- Vafaeimehr, R., & Baleghizadeh, S. (2020). EFL Learners' Perceptions and Practices of Reflective Assessment and Its Impact on Their General English Achievements. *Language Related Research*, 11(3), 347–377.
- Wang, C. H., Salisbury-Glennon, J. D., Dai, Y., Lee, S., & Dong, J. (2022). Empowering College Students to Decrease Digital Distraction Through the Use of Self-Regulated Learning Strategies. In *Contemporary Educational Technology* (Vol. 14, Issue 4). <https://doi.org/10.30935/cedtech/12456>
- Wang, S. Xiang, Chen, H. Wen, Zhao, Q. Yu, Guo, L. Yang, Deng, X. Yu, Si, W. Guo, & Sun, Z. Qing. (2022). Preserving Scheme for Users' Confidential Information in Smart Grids based on Digital Watermarks and Asymmetric Encryption. *Journal of Central South University*, 29(2), 726–740. <https://doi.org/10.1007/s11771-022-4941-9>
- Widiasari, F., & Zahro, F. (2024). Behavior Management in the Classroom: Improving the Quality of Education through Systematic Optimization of the Learning Environment. *FALASIFA: Jurnal Studi Keislaman*, 15(1), 35–47. <https://doi.org/10.62097/falasifa.v15i1.1787>
- Yakubu, M. A., Sain, Z. H., Lawal, U. S., Arif, M., & Hakim, R. (2025). Student Perceptions of Artificial Intelligence as a Virtual Tutor and Its Relation to Self-Efficacy in Learning. *Indonesian Journal of Progressive Pedagogy*, 01(01), 1–11. <https://doi.org/10.61987/ijpp.v1i1.631>
- Zamroni., Fatmasari, R., Windiyani, T., & Putri, D. F. (2025). Artificial Intelligence as a Tool to Improve the Quality of Job-Ready Graduate Skills in Higher Education. *Proceedings of the 2025 IEEE International Conference on Industry 4.0, Artificial Intelligence, and Communications Technology, IAICT 2025*, 129–136. <https://doi.org/10.1109/IAICT65714.2025.11101572>
- Zhang, D., Fu, M., Zhang, J., Li, Y., Chen, L., Chen, Y. J., Zhong, Z., & Zhang, Y. P. (2025). Evaluating Whether Nonimmersion Virtual Reality Simulation Training Improves Nursing Competency in Isolation Wards: Randomized Controlled Trial. *Journal of Medical Internet Research*, 27. <https://doi.org/10.2196/63131>

Zhang, Y. (2023). Construction of a Smart Classroom for Image Processing Courses in Colleges and Universities Based on Artificial Intelligence: Taking Fundamentals of Photoshop as an Example. In *Proceedings of the 3rd IEEE International Conference on Social Sciences and Intelligence Management, SSIM 2023* (pp. 84–88). <https://doi.org/10.1109/SSIM59263.2023.10469561>