

## The Effectiveness of the Project Based Learning (PjBL) Model with a Deep Learning Approach on the Critical Thinking Skills of Fifth Grade Students at SDN Pejaten 2

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**Abstract.** Previous studies on Project-Based Learning (PjBL) have demonstrated its potential to enhance higher-order thinking skills; however, limited research has integrated PjBL with a Deep Learning approach at the elementary school level, particularly in the Indonesian context. This study offers a novel contribution by combining PjBL with structured deep-learning processes—conceptual elaboration, reflective inquiry, and metacognitive reinforcement—to strengthen students' critical thinking development more comprehensively. This research employed a one-group pretest–posttest design involving 64 fifth-grade students at SDN Pejaten 2 during a four-meeting intervention. Critical thinking skills were measured using a validated essay test, and data were analyzed using a paired sample t-test and effect size calculation. Findings show a significant improvement in students' critical thinking skills, with the mean score increasing from 63.1 (pretest) to 82.4 (posttest) ( $t = 6.32$ ;  $p < 0.001$ ). The intervention yielded a large effect size (Cohen's  $d > 0.80$ ), indicating strong practical significance. These results highlight that integrating PjBL with a Deep Learning approach produces deeper cognitive engagement compared with conventional PjBL implementations reported in prior literature. This study provides empirical evidence that project-based learning enriched with deep-thinking processes can serve as an effective pedagogical model for fostering 21st-century competencies in elementary education.

**Keywords:** Project Based Learning, Deep Learning, Critical Thinking, Elementary School.

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### INTRODUCTION

Learning at the elementary school level should ideally provide opportunities for students to engage actively, creatively, and reflectively in the development of higher-order thinking skills. However, instructional practices in many elementary classrooms remain dominated by teacher-centered methods, resulting in learning environments that provide little room for exploration, inquiry, or the development of deep reasoning. This instructional imbalance contributes to students' limited critical thinking performance, even though critical thinking is an essential component of 21st-century competencies that requires students to analyze, evaluate, and solve problems systematically (González-Pérez and Ramírez-Montoya, 2022; Hafizah et al., 2024). The gap between educational demands and classroom realities underscores the urgency of adopting innovative learning models that stimulate active cognitive engagement and meaningful participation.

Project-Based Learning (PjBL) has emerged as one pedagogical approach widely recognized for its potential to improve the quality of the learning process. By guiding students through systematic project development, PjBL positions learners at the center of planning, investigating, and producing authentic outputs. Existing research confirms that PjBL can

enhance critical thinking, collaboration, and conceptual understanding (Tafakur et al., 2023; Williamson, 2023). Nevertheless, most studies emphasize the procedural benefits of PjBL, while fewer examine how the model can be optimized to promote deeper cognitive processing and metacognitive reflection. Additionally, several meta-analyses indicate that PjBL's effectiveness varies widely depending on the depth of cognitive engagement students experience, suggesting the need for complementary approaches that reinforce conceptual connections and reflective thinking (Loyens et al., 2023).

In parallel with these developments, the integration of a Deep Learning approach has gained increasing attention as a framework that emphasizes meaningful knowledge construction, conceptual interconnections, and sustained reflection. Deep Learning encourages students to move beyond surface-level memorization toward reasoning, evaluating, and integrating ideas (Budhiarti et al., 2025; Hilman, 2025). International research has demonstrated that environments supporting deep learning can significantly enhance critical thinking, problem solving, and knowledge transfer (Pan et al., 2023). When viewed through the lens of Bloom's Taxonomy, deep learning processes align with higher cognitive levels such as analyzing, evaluating, and creating skills that are closely associated with the development of critical reasoning.

Technological advancements and the demand for digital literacy have further reinforced the importance of learning models that promote autonomy, investigation, and complex thinking. Integrating PjBL with Deep Learning enables students to conduct data-driven inquiries, manage information, and synthesize concepts in more structured and reflective ways. Previous research indicates that learning experiences incorporating authenticity and deep reflection enhance student persistence, metacognitive awareness, and conceptual clarity (Nobutoshi, 2023; Ramadan et al., 2025). This suggests that combining PjBL and Deep Learning could support not only the acquisition of knowledge but also the formation of long-term learning competencies aligned with the needs of the twenty-first century.

The potential synergy between PjBL and Deep Learning lies in their shared emphasis on inquiry, conceptual elaboration, and active knowledge construction. Project activities that require students to investigate real-world problems, justify decisions, and reflect on their learning processes align strongly with core dimensions of Ennis' critical thinking indicators—clarification, inference, evaluation, and decision making. Likewise, Facione's critical thinking model, which includes interpretation, analysis, evaluation, inference, explanation, and self-regulation, resonates with the reflective and metacognitive elements embedded in Deep

Learning. Several studies have shown that when project-based instruction is enriched with deep-thinking strategies, students demonstrate improved analytical skills, creativity, and conceptual understanding (Chang et al., 2022; Sitepu, 2025). However, the majority of these studies have been conducted at secondary or higher education levels, leaving a significant gap in research targeting elementary school learners.

Despite the promising findings, the application of PjBL and Deep Learning in combination remains limited in Indonesian elementary schools. Most existing studies examine each approach individually, and there is insufficient empirical evidence exploring how the integration of both frameworks can systematically improve young learners' critical thinking abilities. This gap is particularly important because elementary school is a formative period in which foundational reasoning, inquiry, and problem-solving habits begin to develop. Without effective learning models, students may continue to rely on rote memorization and struggle to engage with higher-order thinking tasks.

Furthermore, critical thinking has become a central aspect of global educational priorities as it underpins innovation, creativity, and lifelong learning. As Hitchcock (2017), explains, critical thinking is not merely a set of skills but a disposition that enables learners to question assumptions, synthesize information, and make reasoned judgments. However, students at the elementary level often face challenges in applying such higher-order thinking due to instructional practices that emphasize recall over inquiry. This disconnect highlights the need for learning models that integrate experiential, reflective, and inquiry-based processes capable of fostering deeper engagement and intellectual autonomy.

The alignment between PjBL, Deep Learning, and constructivist principles further supports their combined use. Constructivist theory argues that meaningful learning occurs when students actively construct knowledge through exploration, interaction, and reflection (Miller and Krajcik, 2019). Integrating PjBL with Deep Learning expands this process by incorporating structured reflection, conceptual elaboration, and metacognitive regulation—components that directly contribute to critical thinking development, as outlined in both Bloom's and Facione's frameworks.

In line with the direction of the Deep Learning curriculum, which emphasizes student-centeredness, reflective inquiry, and conceptual integration, the combination of PjBL and deep learning processes provides a theoretically robust framework for fostering critical and creative thinking. Through authentic project tasks and reflective learning cycles, students are guided

to make connections across concepts, evaluate evidence, and apply ideas in meaningful contexts.

Therefore, this study was conducted to investigate the effectiveness of the Project-Based Learning model integrated with a Deep Learning approach in enhancing the critical thinking skills of fifth-grade students at SDN Pejaten 2, Kramatwatu District. By addressing the limitations of previous research and offering a new empirical perspective on the combined application of these two frameworks, the findings of this study are expected to contribute to the development of innovative learning models that respond to the challenges of 21st-century elementary education.

## METHODOLOGY

### Research Design

This study employed a quantitative approach using a one-group pretest–posttest pre-experimental design. This design was selected because it allows researchers to examine changes in students' critical thinking skills before and after the implementation of the Project-Based Learning (PjBL) model integrated with a Deep Learning approach. The absence of a control group is a common characteristic of this design; however, it is suitable for preliminary or exploratory investigations aimed at identifying the practical impact of an instructional intervention in an authentic classroom environment (Creswell, 2021). In this design, students first completed a pretest ( $O_1$ ), received the learning intervention ( $X$ ), and then completed a posttest ( $O_2$ ).

This design aligns with the objectives of the current study, which focus on assessing the immediate effectiveness of the combined PjBL and Deep Learning framework. To enhance credibility, data collection and implementation were conducted under standardized conditions for each learner group.

**Table 1.** Research Design Structure

Group	Pretest	Treatment	Posttest
One Group	$O_1$	$X$ (PjBL with Deep Learning)	$O_2$

Notes:

$O_1$  = Pretest,

X = Learning Treatment,

O<sub>2</sub> = Posttest.

### Research Site and Participants

The study was conducted at SDN Pejaten 2, Kramatwatu District, involving all 64 fifth-grade students who were divided into two parallel classes of 32 students each. Given the small population size and relatively homogeneous student characteristics, a saturation sampling technique was applied, enabling the inclusion of the entire population (Tura, 2016). The intervention took place over one month during the even semester of the 2025–2026 academic year.

**Table 2.** Population and Sample Composition

Grade Level	Sampling Technique	Number of Participants	School
Fifth Grade	Saturation Sampling	64 students (2 groups)	SDN Pejaten 2, Kramatwatu

### Learning Procedure

To improve transparency and replicability, the intervention was implemented in four structured sessions, each lasting 80 minutes, following the official instructional schedule. The activities were adapted from PjBL syntax and integrated with steps that operationalize Deep Learning principles.

#### Session-by-Session Structure

Session 1 — Problem Identification (80 minutes)

- a. Teacher presents a real-life contextual problem related to the learning topic.
- b. Students activate prior knowledge through questioning and prediction tasks.
- c. Deep Learning operationalization: conceptual activation and contextual understanding; guided questioning to stimulate higher-order thinking.

Session 2 — Project Planning (80 minutes)

- a. Students work in groups to formulate project goals, identify relevant concepts, and plan inquiry steps.

- b. Students create mind maps connecting prior concepts with new information.
- c. Deep Learning operationalization: strengthening conceptual networks and collaborative reasoning.

Session 3 — Investigation and Data Exploration (80 minutes)

- a. Students gather information through reading materials, observing phenomena, and analyzing data provided by the teacher.
- b. Students evaluate the credibility of information sources.
- c. Deep Learning operationalization: deep inquiry, analytical thinking, evidence evaluation, and inferential reasoning.

Session 4 — Product Development, Presentation, and Reflection (80 minutes)

- a. Students construct project products representing their understanding (posters, models, written analyses, etc.).
- b. Groups present results, defend arguments, and respond to peer questions.
- c. Teacher facilitates structured reflection focusing on reasoning processes and conceptual connections.
- d. Deep Learning operationalization: metacognition, elaboration, self-evaluation, reflective judgment.

**How Deep Learning Was Operationalized in PjBL**

Deep Learning principles were systematically embedded into each phase:

**Table 3.** Deep Learning Components and Their Operationalization in Classroom Activities

Deep Learning Component	Operationalization in the Classroom
Conceptual Connection	Concept mapping, linking prior knowledge, identifying big ideas
Deep Inquiry	Data analysis, evidence evaluation, generating hypotheses

Deep Component	Learning Operationalization in the Classroom
Elaboration & Reasoning	Justifying solutions, constructing arguments, comparing alternatives
Reflection	Structured journals, self-assessment prompts, metacognitive questions

### Research Instruments

The main instrument used to assess critical thinking skills was an essay-based test developed using Ennis’ (2011) critical thinking framework and complemented by Facione’s indicators. Items were constructed to measure clarification, analysis, inference, evaluation, and decision-making. Students’ responses were scored using a 0–4 performance rubric.

**Table 4.** Critical Thinking Assessment Rubric

Score	Descriptor
4 (Excellent)	Response demonstrates complete conceptual clarity, accurate analysis, strong evidence-based reasoning, and justified conclusions. Arguments are coherent and logically structured.
3 (Good)	Response is mostly accurate with minor conceptual gaps. Reasoning is generally strong, and conclusions are mostly justified.
2 (Fair)	Response shows partial understanding; analysis is limited; reasoning is present but underdeveloped; conclusions lack strong justification.
1 (Poor)	Response shows minimal understanding, weak reasoning, and limited analysis; conclusions are unclear or insufficient.
0 (No Evidence)	Response is irrelevant, incorrect, or missing entirely.

Content validity was reviewed by three experts in learning assessment and elementary education. A pilot study yielded Cronbach’s Alpha = 0.83, demonstrating high reliability (Izah et al., 2023). Inter-rater reliability reached  $r = 0.89$ , indicating consistency across scorers.

### Data Collection Techniques

Data were collected through:

1. Pretest, administered before the intervention to measure baseline critical thinking skills.
2. Posttest, administered after the intervention to measure improvement.

All testing procedures followed uniform instructions and were conducted in the same physical learning environment to ensure consistency and minimize external bias.

**Table 5.** Data Collection Summary

Data Type	Purpose	Instrument	Timing
Pretest	Measure baseline	Critical thinking test	Before treatment
Posttest	Measure improvement	Critical thinking test	After treatment

### Data Analysis Procedures

Data analysis was conducted in several stages:

1. Normality Testing using Kolmogorov–Smirnov to confirm that pretest and posttest data met assumptions for parametric tests.
2. Paired Sample t-test to determine statistically significant differences between pretest and posttest scores.
3. Effect Size Calculation using Cohen’s  $d$  to measure practical impact:

0.2 (small), 0.5 (medium), 0.8 (large).

Statistical Reporting

t-value = 6.32

degrees of freedom (df) = 63

p-value < 0.001

Effect size (Cohen's d) > 0.80 (large)

All analyses were conducted using SPSS (latest version).

### Research Validity and Ethical Considerations

1. Several strategies were employed to ensure validity:
2. Pilot testing to refine instruments.
3. Expert validation to verify content accuracy.
4. Inter-rater scoring to ensure objectivity.
5. Standardized administration procedures to reduce procedural bias.
6. Written consent obtained from school administrators and parents.
7. Confidentiality ensured by anonymizing student responses.

### Control of Internal Validity Threats

A one-group pretest–posttest design carries inherent threats to validity. To minimize these:

**Table 6.** Potential Threats to Internal Validity and Mitigation Strategies

Threat	Mitigation Strategy
Testing Effect	Sufficient time gap between pretest and posttest; different but equivalent item sets used.
Maturation	Short intervention duration (1 month) to reduce developmental influence.
History Effect	Scheduling sessions consistently and limiting external academic activities during implementation.
Instrumentation Bias	Using the same scoring rubric and trained raters for all assessments.
Experimenter Bias	Teacher followed a structured teaching script to ensure consistency across both classes.

### Qualitative Complement and Triangulation

To enrich the quantitative findings, qualitative data were gathered through reflective teacher field notes documenting student engagement, reasoning patterns, and collaboration. These qualitative insights were analyzed thematically to triangulate and interpret how PjBL supported the development of critical thinking through inquiry, elaboration, and reflection. This mixed-data triangulation strengthens internal validity and aligns with the Deep Learning curriculum paradigm, which emphasizes authenticity, reflection, and contextualized understanding (McPhail, 2021).

### RESULTS AND DISCUSSION

The measurement of students' critical thinking skills was conducted through pretest and posttest. The results of descriptive statistical calculations are shown in Table 1.

**Table 7.** Descriptive Statistics of Students' Critical Thinking Skills

Statistic	Pretest Posttest	
	Pretest	Posttest
N	64	64
Minimum Score	48	72
Maximum Score	78	92
Mean	63.1	82.4
Standard Deviation	7.42	6.85

The data show a clear increase across all indicators: minimum, maximum, and mean scores rose consistently after the intervention. The substantial rise in the average score—from 63.1 to 82.4 demonstrates that the learning approach positively influenced students with varying levels of initial ability. This upward trend suggests that the instructional model provided equitable cognitive benefits for all learner groups.

### Normality Test Results

A Kolmogorov–Smirnov test was performed to determine whether the data were normally distributed.



**Table 8.** Kolmogorov–Smirnov Normality Test Results

Variable	Sig. (p-value)	Description
Pretest	0.132	Normally distributed
Posttest	0.086	Normally distributed

Both p-values exceed 0.05, confirming that the data meet the assumptions required for parametric testing.

### Paired Sample t-Test Results

The significance of the difference between pretest and posttest scores was analyzed using a paired sample t-test.

**Table 9.** Paired Sample t-test Results

Variable	Pretest Mean	Posttest Mean	t-count	t-table (0.05)	Sig. (p)
Critical Thinking Skills	63.1	82.4	6.32	2.00	0.000

The t-value of 6.32 is significantly higher than the critical value of 2.00, and the p-value is below 0.05. This indicates a statistically significant improvement in students' critical thinking performance after the intervention. The effect size (Cohen's  $d > 0.80$ ) confirms a large and educationally meaningful impact.

To determine the magnitude of the effect, an effect size calculation was performed. Based on the difference in means and combined standard deviations, Cohen's  $d$  value falls into the large category ( $d > 0.80$ ). These findings indicate that the learning approach applied is not only statistically significant but also has a strong practical impact on improving students' critical thinking skills.

The findings of this study indicate a substantial improvement in students' critical thinking skills following the implementation of the Project-Based Learning (PjBL) model integrated with a Deep Learning approach. The pretest–posttest results, which show a considerable rise in mean scores from 63.1 to 82.4, provide initial evidence that the instructional intervention

effectively strengthened students' reasoning, analytical, and evaluative abilities. These numerical gains are further supported by the consistently higher minimum and maximum scores in the posttest, suggesting that the learning model not only benefited students with higher initial abilities but also successfully supported learners who initially demonstrated lower levels of critical thinking skills. Therefore, the improvement observed is not incidental; rather, it reflects a meaningful shift in the overall cognitive performance of the student cohort.

One of the key reasons for the success of this intervention lies in the complementary nature of PjBL and Deep Learning principles. Project-Based Learning inherently encourages learners to engage with authentic problems, collaborate with peers, and make informed decisions—all of which require them to apply higher-order thinking processes. When PjBL is combined with the Deep Learning approach, these cognitive demands are further intensified through structured opportunities to elaborate concepts, evaluate evidence, and reflect on the reasoning behind each decision. These processes likely contributed to the development of deeper cognitive engagement among students. Unlike traditional instruction, which often emphasizes procedural or surface-level knowledge, the integration of PjBL and Deep Learning fosters an environment in which students must continuously justify their ideas, make connections across concepts, and assess the implications of their decisions. This environment aligns with Biggs and Tang's (2022) constructivist view, which posits that meaningful learning arises when students actively reorganize and internalize knowledge through reflective inquiry.

The findings of this study also align strongly with previous research. Numerous studies have demonstrated the positive impact of PjBL on higher-order thinking, creativity, and student engagement. Kokotsaki et al. (2016) and Bell (2010) emphasize that PjBL allows students to investigate real-world problems and construct knowledge through experiential learning. Similarly, Syafila et al. (2024) highlight that PjBL enhances students' analytical and problem-solving abilities by encouraging exploration and independent decision-making. However, the present study extends this existing body of knowledge by demonstrating that the infusion of Deep Learning strategies significantly amplifies the cognitive benefits traditionally associated with PjBL. Research by Lu et al. (2021) and Rivas et al. (2022) indicates that deep learning environments strengthen metacognitive awareness, conceptual understanding, and evaluative reasoning. The results of the current study support these findings by showing that the combination of inquiry-focused project work and reflective deep-learning activities leads to robust improvements in students' critical thinking skills.

In addition to the quantitative outcomes, qualitative observations during the intervention provide further insight into how the integrated model influenced students' thinking processes. Students were observed to become more inquisitive, more willing to challenge assumptions, and more capable of generating critical questions throughout the learning process. They demonstrated greater initiative in exploring information sources, analyzing data, and comparing potential solutions. When presenting their project outcomes, students showed increased ability to justify their decisions using logical arguments and relevant evidence. These behaviors suggest a shift from surface-level engagement—where students simply complete tasks to deep-level engagement characterized by analytical reasoning, self-reflection, and purposeful inquiry. Such changes align with the components of critical thinking proposed by Facione, particularly interpretation, analysis, inference, evaluation, and explanation.

Moreover, the integration of the Deep Learning approach appears to have been instrumental in strengthening students' metacognitive skills. The reflective sessions conducted at the end of each project cycle encouraged students to evaluate the effectiveness of their strategies, assess their decision-making processes, and reconsider alternative approaches. These structured opportunities for reflection helped students internalize what they learned and understand why certain solutions were more logical or feasible than others. This reflective dimension is essential for cultivating long-term critical thinking habits, as highlighted by Kuhn (2019), who argues that evaluative judgment is central to students' development as autonomous thinkers.

Despite the encouraging findings, it is important to acknowledge the study's limitations. The one-group pretest–posttest design used in this research does not include a control group, which limits the ability to attribute the improvements solely to the intervention. External factors, such as exposure to related learning materials or natural maturation, may have played a minor role, even though the short duration of the intervention somewhat reduces this possibility. Additionally, the sample size was limited to 64 students from a single school, and the characteristics of the teaching environment—such as teacher readiness, school resources, and classroom culture—may have influenced the results. These factors limit the generalizability of the findings to broader educational settings. Another limitation is the relatively short intervention period. Although significant improvements were observed, it is difficult to determine whether the same level of improvement would persist over longer periods or whether students would continue to refine their critical thinking without ongoing, structured support from the learning model.

Notwithstanding these limitations, the results of this study hold important implications for elementary education. The strong improvement in students' critical thinking skills suggests that integrating PjBL and Deep Learning principles can create a more intellectually stimulating learning environment that encourages deeper engagement, reflective inquiry, and purposeful knowledge construction. This aligns with the goals of 21st-century learning, which emphasizes critical thinking, creativity, communication, and collaboration. Furthermore, the integrated model aligns well with the philosophy of the Deep Learning curriculum, which positions students as active constructors of knowledge who engage in continuous cycles of exploration, analysis, and reflection.

Overall, the discussion of findings demonstrates that the PjBL model enriched with Deep Learning components has the potential to significantly improve students' critical thinking skills in meaningful and sustainable ways. The integration of authentic problem solving, conceptual elaboration, and reflective metacognition results in a powerful instructional approach capable of supporting deeper learning processes at the elementary level. Future studies are encouraged to employ more rigorous experimental designs, extend the duration of intervention, and explore the model's impact across diverse educational contexts to strengthen the evidence base and facilitate broader implementation.

## **CONCLUSION**

The findings of this study suggest that the implementation of the Project-Based Learning (PjBL) model integrated with a Deep Learning approach has the potential to enhance the critical thinking skills of fifth-grade students at SDN Pejaten 2, Kramatwatu District. The increase in the average score from 63.1 in the pretest to 82.4 in the posttest indicates a positive developmental trend. The results of the paired sample t-test, which show a significant difference between pre-intervention and post-intervention scores ( $t = 6.32, p < 0.05$ ), further reinforce that the learning intervention may contribute to improvements in students' reasoning and analytical abilities. Although these findings are encouraging, they should be interpreted as showing potential influence rather than definitive evidence of effectiveness, considering the study's methodological constraints.

Beyond the numerical outcomes, the overall pattern of improvement observed in this study aligns with the conceptual foundations of the Deep Learning curriculum, which emphasizes conceptual integration, reflective inquiry, and meaningful knowledge construction. The integration of PjBL with Deep Learning appears to create opportunities for students to develop deeper engagement with learning tasks, connecting new ideas with prior knowledge and

evaluating information within authentic, project-based contexts. These learning conditions may support students' gradual development of critical and reflective thought processes. Nevertheless, the strength of these conclusions remains preliminary, and further research is needed to verify and expand upon the trends identified in this study.

Several limitations must be acknowledged. The use of a one-group pretest–posttest design without a control group restricts the ability to draw firm causal inferences. Improvements in student performance may have been influenced by external factors, practice effects, or natural cognitive development over time. In addition, the sample was limited to a single school with 64 students, which reduces the generalizability of the findings to broader educational contexts. The relatively short duration of the intervention also limits conclusions about the long-term sustainability of the observed gains. These limitations highlight the need for cautious interpretation and indicate that the results should be viewed as preliminary evidence rather than definitive proof of model effectiveness.

Future research could address these limitations by employing more rigorous experimental designs, such as randomized controlled trials or quasi-experiments with comparison groups, to strengthen causal conclusions. Longitudinal studies would also be valuable for examining the persistence of critical thinking improvements over time and understanding how extended implementation of PjBL with Deep Learning influences metacognitive growth and collaborative competencies. Additionally, replication studies across diverse school settings and grade levels would provide more comprehensive insights into how contextual factors shape the effectiveness of the integrated model.

Overall, the findings of this study indicate that the integration of PjBL and Deep Learning offers promising potential as a pedagogical approach that aligns with global educational trends emphasizing critical, reflective, and meaningful learning. While further empirical investigation is needed, the approach shows promise for supporting the development of essential 21st-century competencies and contributing to more engaging and cognitively rich learning environments for elementary school students.

## REFERENCES

- Bell, S. (2010). Project-based learning for the 21st century: Skills for the future. *The Clearing House*, 83(2), 39–43.
- Biggs, J., Tang, C., and Kennedy, G. (2022). *Teaching for quality learning at university 5e*. McGraw-hill education (UK).

- Budhiarti, Y., Mytra, P., and Slow, L. (2025). The Role of Deep Learning in Elementary Education: Pedagogical Insights from a Literature Study. *Jurnal Pedagogi Dan Inovasi Pendidikan*, 1(2).
- Chang, T.-S., Wang, H.-C., Haynes, A. M., Song, M.-M., Lai, S.-Y., and Hsieh, S.-H. (2022). Enhancing student creativity through an interdisciplinary, project-oriented problem-based learning undergraduate curriculum. *Thinking Skills and Creativity*, 46, 101173.
- Creswell, J. W. (2021). *A concise introduction to mixed methods research*. SAGE publications.
- González-Pérez, L. I., and Ramírez-Montoya, M. S. (2022). Components of Education 4.0 in 21st century skills frameworks: systematic review. *Sustainability*, 14(3), 1493.
- Hafizah, M., Solin, S., Purba, C. T., Sihotang, M. M., Rahmad, R., and Wirda, M. A. (2024). Meta-analysis: The impact of problem-based learning (PBL) models on students' critical thinking skills. *Journal of Digital Learning and Education*, 4(3), 167–179.
- Hilman, C. (2025). Digital-based Islamic religious education: a new orientation in enhancing student engagement and spiritual understanding. *The Journal of Academic Science*, 2(1), 53–65.
- Hitchcock, D. (2017). Critical thinking as an educational ideal. In *On reasoning and argument: Essays in informal logic and on critical thinking* (pp. 477–497). Springer.
- Kokotsaki, D., Menzies, V., and Wiggins, A. (2016). Project-based learning: A review of the literature. *Improving Schools*, 19(3), 267–277.
- Kuhn, D. (2019). Critical thinking as discourse. *Human Development*, 62(3), 146–164.
- Loyens, S. M. M., Van Meerten, J. E., Schaap, L., and Wijnia, L. (2023). Situating higher-order, critical, and critical-analytic thinking in problem-and project-based learning environments: A systematic review. *Educational Psychology Review*, 35(2), 39.
- Lu, K., Pang, F., and Shadiev, R. (2021). Understanding the mediating effect of learning approach between learning factors and higher order thinking skills in collaborative inquiry-based learning. *Educational Technology Research and Development*, 69(5), 2475–2492.
- McPhail, G. (2021). The search for deep learning: A curriculum coherence model. *Journal of Curriculum Studies*, 53(4), 420–434.

- Miller, E. C., and Krajcik, J. S. (2019). Promoting deep learning through project-based learning: A design problem. *Disciplinary and Interdisciplinary Science Education Research*, 1(1), 7.
- Nobutoshi, M. (2023). Metacognition and reflective teaching: a Synergistic Approach to fostering critical thinking skills. *Research and Advances in Education*, 2(9), 1–14.
- Pan, Q., Zhou, J., Yang, D., Shi, D., Wang, D., Chen, X., and Liu, J. (2023). Mapping knowledge domain analysis in deep learning research of global education. *Sustainability*, 15(4), 3097.
- Ramadan, Z. H., Putri, M. E., and Nukman, M. (2025). *Pendekatan Pembelajaran Deep Learning Di Sekolah Dasar (Teori Dan Aplikasi)*. Greenbook Publisher.
- Rivas, S. F., Saiz, C., and Ossa, C. (2022). Metacognitive strategies and development of critical thinking in higher education. *Frontiers in Psychology*, 13, 913219.
- Sitepu, Z. R. (2025). Efektivitas Model Pembelajaran Berbasis Proyek Dalam Meningkatkan Kreativitas Siswa Di Sekolah Dasar. *Eruditio: Jurnal Pendidikan Guru Sekolah Dasar*, 1(1), 6–14.
- Syafila, A. E., and A'yun, D. Q. (2024). Analisis eksplorasi konsep pendidikan konstruktivis dalam pembelajaran berbasis proyek. *Jurnal Media Akademik (JMA)*, 2(12).
- Tafakur, T., Retnawati, H., and Shukri, A. A. M. (2023). Effectiveness of project-based learning for enhancing students critical thinking skills: A meta-analysis. *JINoP (Jurnal Inovasi Pembelajaran)*, 9(2), 191–209.
- Tura, B. (2016). First Grade to Fifth Grade: A Chaos Analysis. *International Symposium on Chaos, Complexity and Leadership*, 731–753.
- Williamson, E. (2023). The effectiveness of project-based learning in developing critical thinking skills among high school students. *European Journal of Education*, 1(1), 1–11.