



The Effect of Problem-Based Learning (PBL) through a Deep Learning Approach on Cognitive Learning Outcomes in Science and Social Studies (IPAS) at Elementary School

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Abstract: The low optimization of science and social studies (IPAS) learning outcomes in elementary schools indicates the need for more meaningful and contextual learning models. This study aimed to analyze the effect of the Problem-Based Learning (PBL) model, using a Deep Learning approach, on fourth-grade students' cognitive learning outcomes. A quantitative, quasi-experimental design was employed. The research subjects comprised 54 students, divided into experimental and control groups. Data were collected using validated and reliable pretest and posttest instruments and analyzed using descriptive statistics, normality and homogeneity tests, N-Gain calculations, and an Independent Samples t-test. The results showed that the experimental class mean score increased from 42.41 to 66.39, while the control class improved from 45.00 to 63.15. The N-Gain score of 0.29 was categorized as low to moderate. Hypothesis testing yielded a p-value of 0.498 (>0.05), indicating no significant difference between the groups. However, the Deep Learning-based PBL model demonstrated a tendency to improve cognitive learning outcomes and has potential for sustainable classroom implementation.

Abstrak: Rendahnya optimalisasi hasil belajar IPAS di sekolah dasar menunjukkan perlunya penerapan model pembelajaran yang lebih bermakna dan kontekstual. Penelitian ini bertujuan menganalisis pengaruh model Problem Based Learning (PBL) melalui pendekatan Deep Learning terhadap hasil belajar kognitif siswa kelas IV. Penelitian menggunakan pendekatan kuantitatif dengan desain quasi eksperimen. Subjek penelitian berjumlah 54 siswa yang terbagi dalam kelas eksperimen dan kontrol. Data dikumpulkan melalui tes pretest dan posttest yang telah diuji validitas dan reliabilitasnya, kemudian dianalisis menggunakan statistik deskriptif, uji normalitas, homogenitas, perhitungan N-Gain, serta Independent Samples t-test. Hasil penelitian menunjukkan rata-rata nilai kelas eksperimen meningkat dari 42,41 menjadi 66,39, sedangkan kelas kontrol dari 45,00 menjadi 63,15. Nilai N-Gain sebesar 0,29 termasuk kategori rendah-sedang. Uji hipotesis menunjukkan nilai signifikansi 0,498 ($>0,05$) sehingga tidak terdapat perbedaan signifikan antar kelas. Meskipun demikian, model PBL berbasis Deep Learning menunjukkan kecenderungan peningkatan hasil belajar dan berpotensi meningkatkan kualitas pembelajaran IPAS secara berkelanjutan.

A. Introduction

Elementary education plays a strategic role in building students' foundational knowledge, attitudes, and higher-order thinking skills. At this stage, learning is not merely about knowledge transmission but also about developing critical thinking, problem-solving, and the ability to connect academic concepts with real-life contexts (Bransford et al., 2000; Fitriani, 2021). The demands of 21st-century education emphasize creativity, collaboration, communication, and critical thinking as essential competencies that should be cultivated from early schooling (Nugraha et al., 2023). However, despite curriculum reforms promoting student-centered learning, many elementary classrooms continue to struggle to implement instructional models that foster meaningful, deep understanding (Albina et al., 2022).

Teacher-centered instruction remains dominant in many Indonesian primary classrooms, limiting students' opportunities to actively construct knowledge and engage in inquiry-based exploration (Husna & Munfarichah, 2024; Wirabumi, 2020). Such practices often lead to passive learning, superficial memorization, and limited conceptual transfer. This issue is particularly evident in Science and Social Studies (IPAS), a subject introduced under the Merdeka Curriculum to integrate natural and social sciences into contextual and interdisciplinary learning experiences (Suhelayanti & Rahmawati, 2023). Although IPAS is conceptually designed to promote inquiry and real-world application, instructional implementation often emphasizes mastery of theoretical content rather than higher-order thinking and conceptual integration (Sagita et al., 2023; Hanifah & Supriatna, 2022).

Preliminary observations in a fourth-grade classroom revealed that instruction relied heavily on lectures and simple assignments. Survey data indicated that students' learning readiness was rated as good (82.64%), while their critical thinking and problem-solving skills were rated only moderate (74.42%). Moreover, 39.29% of students had not achieved the minimum mastery criterion (KKTP = 73), demonstrating uneven cognitive achievement across the class. These findings reflect a discrepancy between curriculum expectations and classroom realities. Similar concerns have been reported in previous national studies, highlighting the need for more innovative, student-centered instructional strategies in elementary IPAS learning (Sarief, 2022; Jannati et al., 2025).

To address these challenges, instructional models that promote active engagement and deep conceptual understanding are required. One widely recognized approach is Problem-Based Learning (PBL), which encourages students to construct knowledge through authentic problem-solving, collaboration, and inquiry (Hmelo-Silver, 2004; Savery, 2006). PBL aligns with constructivist learning theory, emphasizing that knowledge is actively constructed through interaction and reflection rather than passively received (Bransford et al., 2000). Empirical evidence indicates that PBL can enhance students' critical thinking skills, conceptual understanding, and long-term retention when properly implemented (Prince, 2004; Strobel & van Barneveld, 2009). In Indonesian contexts, PBL has also been shown to improve communication skills and collaborative learning behaviors and learning outcomes (Aini & Utomo, 2019; Yunita & Maisyaroh, 2021).

However, research also suggests that PBL's effectiveness depends on the quality of scaffolding and instructional guidance (Kirschner et al., 2006). Minimally guided instruction without structured support may lead to cognitive overload, especially among younger learners. Therefore, integrating a complementary approach that reinforces conceptual depth and reflection is crucial. The Deep Learning approach offers such reinforcement by emphasizing meaningful learning, conceptual connections, and reflective thinking (Biggs & Tang, 2011; Entwistle & Ramsden, 1983). Deep learning contrasts with surface learning, which focuses primarily on memorization without conceptual integration. Students who adopt deep approaches tend to achieve higher conceptual understanding and better knowledge transfer (Loyens et al., 2008).

In elementary education, deep learning principles can encourage students to relate scientific and social phenomena to real-life experiences, thereby enhancing cognitive engagement and intrinsic motivation (Amalia et al., 2025; Warman et al., 2025). Research in Indonesian primary schools suggests that deep learning strategies can improve students' conceptual mastery and reflective thinking skills (Sitompul et al., 2025; Latif & Sriyati, 2020; Wahyudi & Budiyanto, 2018). Furthermore, educational innovation studies highlight that integrating reflective conceptual reinforcement within inquiry-based models strengthens students' cognitive processing (Suwandi & Sulastri, 2024).

Although numerous studies have investigated the effectiveness of PBL (Hmelo-Silver, 2004; Savery, 2006) and deep approaches to learning (Biggs & Tang, 2011; Entwistle & Ramsden, 1983), most research has been conducted in higher education or secondary school contexts (Prince, 2004; Loyens et al., 2008). In Indonesia, research tends to examine PBL and deep learning separately, focusing on student engagement or general learning outcomes rather than specifically analyzing cognitive achievement in integrated IPAS instruction (Sagita et al., 2023; Sarie, 2022). Limited empirical studies have examined the combined implementation of PBL and Deep Learning in elementary IPAS learning within the Merdeka Curriculum framework (Surya & Putri, 2022; Pratiwi & Laksmiwati, 2021). This indicates a significant research gap concerning how these two approaches interact to influence cognitive learning outcomes in primary education settings.

The present study addresses this gap by integrating Problem-Based Learning with a Deep Learning approach in fourth-grade IPAS instruction. Unlike previous studies that treated PBL as a standalone inquiry-based model (Savery, 2006) or examined deep approaches as individual learning orientations (Biggs & Tang, 2011), this research embeds deep learning principles within structured PBL stages. The integration ensures that problem-solving activities are accompanied by guided reflection, conceptual reinforcement, and meaningful knowledge construction. This pedagogical synthesis aligns with constructivist principles (Bransford et al., 2000) while addressing concerns about insufficient instructional guidance (Kirschner et al., 2006). By systematically combining inquiry-based problem-solving with reflective conceptual deepening, this study proposes a more comprehensive instructional framework for elementary IPAS learning.

Based on the identified gap, this study addresses the following research question: Does the integration of Problem-Based Learning through a Deep Learning approach significantly influence fourth-grade students' cognitive learning outcomes in IPAS?. Theoretically, this study contributes to the literature on student-centered and meaningful learning models by providing empirical evidence from primary education contexts (Prince, 2004; Strobel & van Barneveld, 2009). Practically, the findings offer instructional guidance for teachers in designing structured, scaffolded PBL environments that promote conceptual understanding and higher-order thinking skills. From a policy perspective, the results may inform curriculum implementation strategies aligned with the Merdeka Curriculum's emphasis on deep, transferable, and contextual learning outcomes (Biggs & Tang, 2011; Suwandi & Sulastri, 2024).

B. Method

This study employed a quantitative, quasi-experimental design with a nonequivalent control group. The research was conducted at SDN 007 Samarinda Ulu and involved all fourth-grade students as research participants. Since the total population consisted of 54 students and was relatively small, saturated sampling was used, meaning the entire population served as the research sample. The participants were divided into two parallel classes: Class IV C served as the experimental group, while Class IV A functioned as the control group. The experimental class received instructional treatment through the implementation of the Problem-Based Learning (PBL) model integrated with a Deep Learning approach. In contrast, the control class was taught using conventional instructional methods commonly practiced by the classroom teacher. Based on preliminary academic records and teacher evaluation, both classes were considered to have relatively equivalent initial abilities.

The independent variable in this study was the implementation of Problem-Based Learning through a Deep Learning approach. In contrast, the dependent variable was students' cognitive learning outcomes in Science and Social Studies (IPAS). Cognitive learning outcomes were operationally defined as students' scores on standardized multiple-choice tests administered before and after the instructional intervention. Data were collected using a written test developed in accordance with fourth-grade IPAS learning achievement indicators aligned with the Merdeka Curriculum. The same instrument was used for both pretest and posttest to ensure measurement consistency. Prior to its administration, the instrument underwent validity and reliability testing. Content validity was examined through expert judgment to ensure alignment with curriculum standards, and reliability was measured using Cronbach's Alpha to determine internal consistency, confirming that the instrument was suitable for assessing students' cognitive achievement.

The research procedure consisted of three main stages. First, both the experimental and control groups were given a pretest to measure students' initial cognitive abilities in IPAS. Second, the treatment phase was implemented, during which the experimental group received instruction through PBL integrated with Deep Learning principles emphasizing

problem orientation, collaborative investigation, guided reflection, conceptual reinforcement, and contextual application. Meanwhile, the control group participated in conventional learning activities characterized by teacher explanations, textbook-based instruction, and individual assignments. Third, after the instructional intervention, both groups were administered a posttest using the same instrument to assess students' cognitive improvement. The overall research procedure is illustrated in Figure 1.

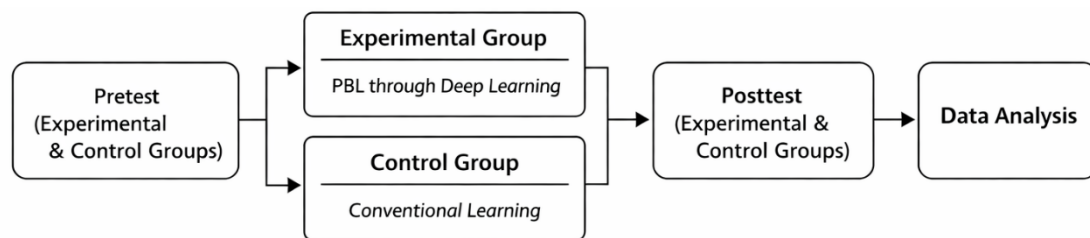


Figure 1. Research Flow

The collected data were analyzed using both descriptive and inferential statistical techniques. Descriptive statistics were used to determine the mean, minimum, maximum, and standard deviation of students' scores. Before conducting hypothesis testing, prerequisite analyses were performed, including normality tests using Kolmogorov-Smirnov and Shapiro-Wilk procedures to assess data distribution, and a homogeneity test using Levene's Test to examine the equality of variances between groups. To determine the magnitude of learning improvement, the N-Gain score was calculated and categorized into low, moderate, or high levels. Hypothesis testing was conducted using the Independent Samples t-test at a significance level of $\alpha = 0.05$. The statistical hypotheses were formulated as follows: H_0 stated that there is no significant effect of Problem-Based Learning through a Deep Learning approach on students' cognitive learning outcomes in IPAS. In contrast, H_a stated that the instructional model has a significant effect on students' cognitive achievement. All statistical analyses were conducted to determine whether integrating PBL and Deep Learning significantly influenced students' cognitive learning outcomes.

C. Result

This study aimed to examine the effect of Problem-Based Learning (PBL) through a Deep Learning approach on fourth-grade students' cognitive learning outcomes in IPAS. The results are presented through descriptive statistics, prerequisite tests, N-Gain analysis, and hypothesis testing.

Descriptive Statistics

Descriptive statistical analysis was conducted to determine students' cognitive achievement before and after the instructional treatment.

Table 1. Descriptive Statistics of Pretest and Posttest Scores

Group	Test	N	Minimum	Maximum	Mean	Std. Deviation
Experimental	Pretest	27	17.5	67.5	42.41	12.45
Experimental	Posttest	27	15.0	90.0	66.39	18.85
Control	Pretest	27	17.5	67.5	45.00	12.65
Control	Posttest	27	22.5	95.0	63.15	18.18

The results indicate that both groups experienced improvement after instruction. The experimental group's mean score increased from 42.41 to 66.39, while the control group improved from 45.00 to 63.15. Although both groups showed progress, the increase in the experimental group was slightly higher.

Normality Test

Normality testing was conducted using the Kolmogorov-Smirnov and Shapiro-Wilk tests to determine whether the data met the assumption of normality.

Table 2. Normality Test Results

Group	Test	Kolmogorov-Smirnov Sig.	Shapiro-Wilk Sig.	Interpretation
Experimental	Pretest	0.065	0.127	Normal
Experimental	Posttest	0.002	–	Not Normal
Control	Pretest	0.060	0.150	Normal
Control	Posttest	0.025	–	Not Normal

The pretest scores in both groups were normally distributed ($p > 0.05$). However, the posttest scores showed slight deviations from normality. Despite this, further analysis proceeded considering sample size and homogeneity results.

Homogeneity Test

Levene's Test was conducted to examine the equality of variances between the experimental and control groups.

Table 3. Homogeneity Test Result (Levene's Test)

Variable	Levene Statistic	df1	df2	Sig.	Interpretation
Posttest Scores	0.090	1	52	0.764	Homogeneous

Levene's Test showed a p-value of 0.764 (> 0.05), indicating that the variances of the experimental and control groups were homogeneous. Therefore, the assumption of equal variances was satisfied, and the Independent Samples t-test could be conducted.

N-Gain Analysis

To determine the magnitude of learning improvement, the normalized gain (N-Gain) score was calculated.

Table 4. N-Gain Analysis

N	Minimum	Maximum	Mean N-Gain	Category
27	-0.45	0.85	0.29	Low-Moderate

The average N-Gain score was 0.29 (29.41%), placing it in the low-to-moderate improvement category. This indicates that although learning improved, the magnitude of the increase was not large.

Hypothesis Testing

Hypothesis testing was conducted using the Independent Samples t-test with a significance level of $\alpha = 0.05$.

Table 5. Independent Samples t-Test Result

t-value	Sig. (2-tailed)	Decision
0.682	0.498	H ₀ Accepted

The t-test results revealed a significance value of 0.498 (> 0.05), indicating that there was no statistically significant difference between the experimental and control groups. Therefore, the null hypothesis (H₀) was accepted. This result suggests that implementing PBL through a Deep Learning approach did not produce a statistically significant effect on students' cognitive learning outcomes compared to conventional instruction.

D. Discussion

This study aimed to examine whether integrating Problem-Based Learning through a Deep Learning approach significantly influences fourth-grade students' cognitive learning outcomes in IPAS. The findings indicate that although both groups demonstrated improvement, the statistical analysis revealed no significant difference between the experimental and control groups ($p = 0.498 > 0.05$). Thus, the research question can be answered by stating that the integrated instructional model did not produce a statistically significant effect during this intervention. Nevertheless, the descriptive statistics and N-Gain results suggest a tendency toward greater improvement in the experimental group, indicating potential instructional value.

The absence of statistical significance does not necessarily imply that the model is ineffective. Instructional innovations often require extended implementation before measurable academic gains become evident. Meta-analytical studies suggest that problem-based and inquiry-based approaches tend to generate stronger effects on conceptual

understanding and transfer when applied over longer instructional periods (Dochy et al., 2003; Gijbels et al., 2005). Similarly, research on learning approaches emphasizes that deep conceptual processing develops gradually through iterative reflection and cognitive restructuring (Marton & Säljö, 1976). Therefore, short-term experimental designs may not fully capture the long-term cognitive benefits of integrative instructional frameworks.

Another important factor concerns the role of scaffolding and guided instruction. Cognitive load research explains that effective learning occurs when instructional support is appropriately structured to match learners' developmental levels (Sweller et al., 2011). In primary education settings, students are still developing self-regulation skills, which makes structured facilitation essential for successful inquiry-based learning (Hmelo-Silver et al., 2007). If scaffolding is insufficient or inconsistently implemented, the potential cognitive advantages of problem-based inquiry may not be fully realized.

Despite the lack of statistical significance, the improvement trend observed in the experimental group reflects meaningful instructional processes. Problem-oriented instruction encourages active information processing, collaborative reasoning, and contextual application of knowledge (Schmidt et al., 2011). Deep learning perspectives further highlight the importance of relational understanding, in which learners connect ideas across contexts rather than memorize isolated facts (Prosser & Trigwell, 1999). These processes may enhance conceptual durability even if immediate test score differences remain modest.

The findings are consistent with previous research indicating that student-centered approaches can improve conceptual understanding, although effect sizes vary depending on the quality of implementation (Walker & Leary, 2009). However, some studies report inconsistent short-term achievement gains in elementary contexts, particularly when learners are adapting to inquiry-based instructional environments (Belland et al., 2015). This suggests that contextual variables, including teacher facilitation skills and instructional duration, significantly influence measurable outcomes.

From a theoretical standpoint, the results indicate that integrating innovative instructional approaches does not automatically ensure significant cognitive gains. Learning effectiveness depends on coherence between instructional design and assessment practices. The principle of constructive alignment emphasizes that assessment methods must reflect the depth and complexity of intended learning outcomes (Biggs, 1996). When assessment instruments primarily measure factual recall, they may underestimate deeper conceptual understanding fostered through inquiry and reflection.

In conclusion, although the statistical results did not demonstrate a significant difference between groups, the integration of Problem-Based Learning and Deep Learning principles shows promising pedagogical potential. Sustained implementation, structured scaffolding, and alignment between instructional and assessment practices are necessary to optimize its impact on elementary students' cognitive development.

E. Implication

The findings of this study carry several important implications for educational practice, theory, and policy in elementary education. Although integrating Problem-Based Learning (PBL) through a Deep Learning approach did not yield a statistically significant effect on students' cognitive learning outcomes, the observed trend of improvement in the experimental group suggests meaningful pedagogical potential. Therefore, instructional innovation in primary classrooms should not be evaluated solely based on short-term statistical significance but also on its influence on learning processes and student engagement.

From a pedagogical perspective, implementing PBL integrated with Deep Learning requires structured scaffolding, clear procedural guidance, and sufficient instructional time. Elementary students may need gradual adaptation to inquiry-based and reflective learning environments. Teachers should provide guided questioning, structured reflection sessions, and contextual reinforcement to help students deepen conceptual understanding. Continuous formative assessment and feedback mechanisms are also essential to ensure that students remain cognitively engaged throughout the learning process. Furthermore, professional development programs should emphasize practical strategies for managing collaborative learning and reflective inquiry in primary classrooms.

Theoretically, this study highlights that integrating innovative learning models does not automatically yield measurable cognitive gains. Instructional effectiveness depends on alignment between learning objectives, teaching strategies, duration of implementation, and assessment instruments. Future instructional design should consider balancing inquiry-based activities with structured conceptual reinforcement to optimize learning outcomes. Additionally, the findings suggest that evaluating deep learning strategies may require broader assessment indicators that capture conceptual understanding, transfer ability, and higher-order thinking skills beyond conventional multiple-choice testing.

From a policy standpoint, the results support the need for sustained curriculum implementation rather than short-term intervention programs. Schools should provide institutional support for innovative learning models by allocating sufficient time, facilitating collaborative teacher planning, and providing classroom resources. Long-term implementation strategies are necessary to allow both teachers and students to adapt effectively to student-centered instructional approaches. Future research is encouraged to explore longer intervention periods, larger sample sizes, and multidimensional outcome measures to understand better the impact of integrated learning models in elementary education.

In summary, while the statistical findings indicate no significant difference, the instructional integration of PBL and Deep Learning shows promising potential to enhance meaningful learning processes. With proper scaffolding, sustained implementation, and contextual adaptation, this approach may improve cognitive development and the overall quality of elementary IPAS instruction.

F. Limitation and Suggestion for Further Research

This study has several limitations that should be acknowledged. First, the duration of the instructional intervention was relatively short, which may not have been sufficient to fully capture the long-term cognitive impact of integrating Problem-Based Learning (PBL) with a Deep Learning approach. Instructional models that emphasize inquiry, reflection, and conceptual restructuring often require sustained implementation before measurable academic differences emerge. Therefore, the short-term nature of the treatment may have influenced the absence of statistically significant results.

Second, the study involved a relatively small sample size drawn from a single elementary school, which may limit the generalizability of the findings. Variations in school context, teacher experience, classroom management practices, and student characteristics could produce different outcomes in broader educational settings. Expanding the research to multiple schools with diverse demographic backgrounds would provide stronger empirical evidence regarding the effectiveness of the integrated instructional model.

Third, this study focused exclusively on cognitive learning outcomes measured through multiple-choice tests. Although such instruments are useful for assessing conceptual mastery, they may not fully capture higher-order thinking skills, reflective abilities, collaborative competence, or long-term knowledge retention. The use of additional assessment methods, such as performance-based tasks, project evaluations, observational rubrics, or qualitative reflections, could provide a more comprehensive understanding of the impact of PBL integrated with Deep Learning.

Given these limitations, future research is recommended to conduct longer-term experimental studies with larger, more diverse samples. Researchers should also consider examining additional variables, including students' motivation, engagement, critical thinking skills, and self-regulated learning abilities. Furthermore, comparative studies exploring different scaffolding intensities or variations in instructional design may help identify optimal implementation strategies for elementary contexts. By addressing these aspects, future investigations can provide deeper insights into how integrated innovative learning models contribute to sustainable improvement in primary education.

G. Conclusion

This study examined the effect of integrating Problem-Based Learning (PBL) through a Deep Learning approach on fourth-grade students' cognitive learning outcomes in IPAS. The findings indicate that both the experimental and control groups improved on posttest scores, but the statistical analysis revealed no significant difference between the groups. Therefore, it can be concluded that the implementation of PBL integrated with a Deep Learning approach did not produce a statistically significant effect on students' cognitive achievement compared to conventional instruction within the duration of this study.

Nevertheless, the descriptive results and N-Gain analysis demonstrated a tendency toward greater improvement in the experimental group, suggesting that the integrated

instructional model holds pedagogical potential. The findings imply that the effectiveness of combining PBL and Deep Learning may depend on factors such as implementation duration, instructional scaffolding, teacher readiness, and students' adaptation to student-centered learning environments.

In conclusion, although the statistical evidence does not confirm a significant impact, integrating PBL and Deep Learning offers a promising framework for fostering meaningful, context-based learning in elementary IPAS instruction. Sustained implementation and structured guidance are recommended to optimize its potential impact on students' cognitive development.

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