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THE EFFECTIVENESS OF DEEP LEARNING-BASED LEARNING WITH A PROJECT-BASED LEARNING MODEL TO IMPROVE STUDENT LEARNING OUTCOMES IN REGIONAL DEVELOPMENT MATERIALS AT SMA NEGERI 4 JAYAPURA CITY

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ABSTRACT
This study examined the effectiveness of integrating a deep learning approach with Project-Based Learning (PjBL) in improving students' learning outcomes in Regional Development at SMA Negeri 4 Kota Jayapura. A quasi-experimental method with a one-group pretest-posttest design was applied to 34 students in class XI D. Data were collected through achievement tests, observations, and documentation, and analyzed using a paired-samples t-test. The results showed a significant improvement in students' learning outcomes, with the mean score increasing from 24.29 on the pretest to 74.96 on the posttest ($t = -29.717$; $p < 0.05$). Observations also indicated a shift in students' understanding from rote memorization to more analytical and contextual reasoning. These findings demonstrate that the integration of a deep learning approach and PjBL effectively supports meaningful geography learning. This study contributes empirical evidence on the effectiveness of the model and provides a contextual instructional approach for teaching regional development at the senior high school level.

INTRODUCTION

Geography education at the senior high school level plays an important role in developing students' spatial thinking and their understanding of regional development processes. In geography, regional development is not merely

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a conceptual topic to be memorized, but a subject that requires students to analyze the interaction of physical, social, and economic factors across space (Selvi Handayani et al., 2025). Therefore, geography learning should encourage students to connect concepts with real regional phenomena and to develop analytical, critical, and reflective thinking skills.

In practice, however, geography learning in schools often remains teacher-centered and concept-oriented. Preliminary observations at SMA Negeri 4 Kota Jayapura showed that classroom instruction still relied predominantly on lectures, with limited student engagement in discussion, analysis, and contextual problem solving. As a result, students tended to understand regional development superficially and had difficulty relating the material to the socio-spatial realities of Papua. This condition indicates the need for an instructional approach that can link conceptual understanding with authentic local issues.

Previous studies have shown that Project-Based Learning (PjBL) can improve learning outcomes and student engagement in geography learning, because it involves students in authentic, inquiry-based, and contextual activities (Budianto et al., 2024). In addition, studies on the Deep Learning approach have emphasized the importance of meaningful, mindful, and durable learning in strengthening conceptual understanding (Panjaitan et al., 2023). Although both approaches have been reported to support active and meaningful learning, most previous studies have examined them separately, while studies that integrate both approaches in geography learning remain limited, especially on regional development material at the senior high school level and within the local context of Papua.

The state of the art of this study lies in the integration of the Deep Learning approach and the PjBL model in geography learning on regional development material by using Jayapura's local context as the basis for project activities and conceptual analysis. This integration is expected not only to improve students' cognitive learning outcomes, but also to strengthen their ability to interpret regional development issues analytically and contextually.

Based on this gap, the present study aims to: (1) analyze the effectiveness of integrating the Deep Learning approach with the PjBL model in improving students' learning outcomes on regional development material at SMA Negeri 4 Kota Jayapura; (2) develop contextual learning tools relevant to students' characteristics and local environmental conditions; and (3) identify changes in students' conceptual understanding before and after the implementation of Deep Learning–based PjBL. This study is expected to contribute empirical evidence and a contextual instructional model for strengthening innovative geography learning in senior high schools, particularly in eastern Indonesia.

RESEARCH METHOD

This study employed a quantitative approach using a quasi-experimental method with a one-group pretest-posttest design. This design was selected to examine the effectiveness of integrating the deep learning approach with the Project-Based Learning (PjBL) model in improving students' learning outcomes in Regional Development material (Hadipuro, 2022). The study was conducted at SMA Negeri 4 Kota Jayapura from May to September 2025. The population consisted of Grade XI students taking geography, and the sample was selected purposively. Class XI D, comprising 34 students, was chosen as the research sample because the class was actively involved in learning activities and willing to participate in project-based tasks.

Data were collected through tests, observations, and documentation. The pretest and posttest were used to measure students' learning outcomes and conceptual understanding of regional development. The test instrument consisted of multiple-choice and essay items developed based on the learning indicators. Content validity was examined through expert judgment, and the instrument showed high reliability (Cronbach's Alpha = 0.86). Observation sheets were used to record students' participation, collaboration, and critical thinking during the learning process, while documentation of classroom activities and project outputs was used to support the interpretation of the findings.

The research procedure consisted of three stages: preparation, implementation, and analysis. During the preparation stage, the researcher coordinated with the school, developed the learning tools, and validated the research instruments. The implementation stage began with the administration of the pretest, followed by the application of

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deep learning–based PjBL in four meetings. In this process, students worked on contextual projects related to regional development in Jayapura City. At the end of the intervention, a posttest was administered to measure changes in students' learning outcomes. The final stage involved data processing and interpretation.

Quantitative data were analyzed using SPSS version 26. A Shapiro-Wilk test was first conducted to examine data normality. Since both pretest and posttest scores were normally distributed, a paired-samples t-test was used to compare students' learning outcomes before and after the intervention at a significance level of 0.05. Observation and documentation data were analyzed descriptively to explain changes in students' engagement and conceptual understanding during the learning process (Nasution, 2023).

This study has several limitations related to its research design. The use of a one-group pretest-posttest design without a control group limits the ability to attribute changes in learning outcomes solely to the intervention, since external factors may also have influenced the results. In addition, the absence of randomization reduces control over potential threats to internal validity. The study was also conducted in a single class within one school, which may limit the generalizability of the findings to other contexts. Therefore, future studies are recommended to employ control groups, larger samples, and broader research settings to strengthen the validity and applicability of the results

RESULTS AND DISCUSSION

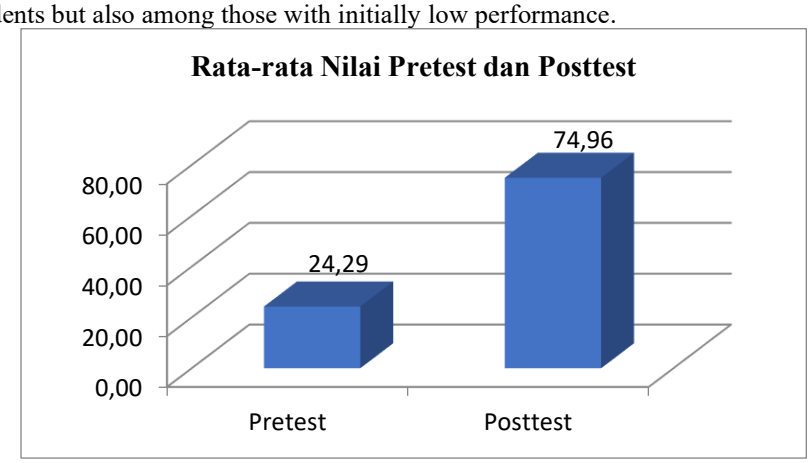
RESULT

This study involved 34 students of Class XI D at SMA Negeri 4 Jayapura City. Learning outcome data were obtained through pretest and posttest scores to measure the impact of the Deep Learning–based Project-Based Learning (PjBL) intervention. A summary of the descriptive statistics for pretest and posttest scores is presented in Table 1.

Tabel 1. *Descriptive Statistics of Pretest and Posttest Scores*

Data	N	Rata-rata	Nilai Minimum	Nilai Maximum	Standar Deviasi
Pretest	34	24.29	11.43	37.14	6.648
Posttest	34	74.96	62.86	94.29	7.127

Descriptive statistical analysis showed a substantial increase in students' learning outcomes after the intervention. The mean score improved from 24.29 in the pretest to 74.96 in the posttest, indicating a gain of 50.67 points. In addition, the minimum score increased from 11.43 to 62.86, while the maximum score rose from 37.14 to 94.29. This consistent upward shift across all score indicators suggests that the improvement occurred not only among high-achieving students but also among those with initially low performance.



Gambar 1. *Average pretest and posttest scores*

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To ensure the validity of parametric testing, a normality test using the Shapiro–Wilk method was conducted. The results of the normality test are presented in Table 2.

Tabel 2. *Results of the Shapiro–Wilk Normality Test*

Data	Statistic	df	Sig.	Keterangan
Pretest	0.954	34	0.157	Normal
Posttest	0.943	34	0.076	Normal

The results showed that the pretest data (Sig. = 0.157) and posttest data (Sig. = 0.076) were both normally distributed ($p > 0.05$). Therefore, the assumption of normality was met, allowing further analysis using a paired-samples t-test. The results of the mean difference test are presented in Table 3.

Tabel 3. *Results of the Paired Sample t-Test*

Pasangan Data	Rerata	Selisih Rerata	t	df	Sig. (2-tailed)
Pretest	23.85	-50.765	-29.717	33	0.000
Posttest	74.62				

The paired-samples t-test revealed a t-value of -29.717 with a significance level (2-tailed) of 0.000 ($p < 0.05$), indicating a statistically significant difference between pretest and posttest scores. This result confirms that the observed improvement in students' learning outcomes is not due to random variation but can be attributed to the instructional intervention.

Furthermore, the magnitude of the mean difference (-50.765) indicates a strong effect of the intervention on students' cognitive achievement. The large difference between pretest and posttest scores suggests that students experienced a substantial shift in their level of understanding, moving from basic recognition of concepts toward more comprehensive and structured knowledge.

The graphical representation of the data (Figure 1) also illustrates a clear and significant increase in average scores, reinforcing the statistical findings. The steep rise in posttest scores visually confirms the effectiveness of the intervention in improving learning outcomes.

In addition to quantitative data, observational results showed notable improvements in students' engagement during the learning process. Students demonstrated increased participation in discussions, active collaboration in group work, and greater involvement in completing project tasks. These behavioral changes support the quantitative findings and indicate that the improvement in test scores was accompanied by enhanced learning processes.

Overall, the statistical and observational results consistently indicate that the implementation of Deep Learning–based Project-Based Learning (PjBL) produced a significant and meaningful improvement in students' learning outcomes.

DISCUSSION

Effectiveness of Deep Learning–Based Project-Based Learning

The main findings of this study demonstrate that the integration of the Deep Learning approach with the Project Based Learning (PjBL) model is effective in improving students' learning outcomes on Regional Development material. The significant increase between pretest and posttest scores ($p < 0.05$) indicates that the instructional intervention had a tangible impact on students' cognitive achievement. This effectiveness is attributable to the complementary characteristics of the two approaches. The PjBL model provides a project-oriented learning framework that requires students to actively explore real-world problems, while the Deep Learning approach ensures that such exploration leads to deep conceptual understanding rather than merely mechanical project completion.

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These findings are consistent with the results reported by Harizah et al (2022), who found that the implementation of the Project-Based Learning model significantly improved students' geography learning outcomes at SMA Negeri 5 Pamekasan (Triana Dewi Harizah et al., 2022). Similarly, Dewi and Rusilowati (2025) demonstrated that the Deep Learning approach effectively enhanced students' conceptual understanding in science learning (Dewi & Rusilowati, 2025). The present study extends previous research by showing that the integration of these two approaches produces a stronger effect, as it addresses the limitations of each approach when implemented independently. PjBL without a deep learning orientation risks reducing projects to technical activities devoid of conceptual meaning, while Deep Learning without a project-based framework may become overly abstract and insufficiently applicable to real-world contexts.

From a learning theory perspective, these findings support the concept of meaningful learning proposed by Ausubel (1968), which posits that meaningful learning occurs when learners are able to relate new information to their existing cognitive structures (Ringgo Ayomi et al., 2025). Regional development projects grounded in the local potential of Jayapura City facilitated the assimilation of theoretical concepts of regional development with students' contextual knowledge of their surrounding environment (Dirk Wabiser et al., 2025). This process aligns with the meaningful element of the Deep Learning approach, as articulated by Abdul Mu'ti, which emphasizes that learning must be meaningful in order for knowledge to be retained over time (durable) and understood with awareness (mindful).

The local context of Jayapura City emerged as a crucial factor in strengthening learning effectiveness. Students did not merely study regional development concepts abstractly through textbooks but also directly observed development phenomena in their surroundings, such as residential expansion, infrastructure development, and interregional disparities. This connection between instructional content and everyday realities enhanced students' learning motivation and increased the relevance of the learning experience (Karsih Asmi & Wijayanto, 2025). When students were tasked with developing regional development proposals for their own residential areas, they perceived a direct stake in the project outcomes, which in turn increased their engagement and sense of responsibility toward the learning process.

Why is the Deep Learning–Based Project-Based Learning model effective

An additional explanation for the effectiveness of the Deep Learning–based Project-Based Learning (PjBL) model lies in the alignment between instructional design and the cognitive processes required for meaningful learning. This model is effective because it integrates three essential dimensions of learning: cognitive engagement, contextual relevance, and active participation. Unlike conventional teacher-centered approaches, which often emphasize passive knowledge reception, this integrated model requires students to actively explore, analyze, and apply concepts through real-world problem-solving activities (Putra et al., 2025). As a result, learning becomes an active process of knowledge construction rather than mere information acquisition.

Moreover, the Deep Learning component ensures that students engage with content at a deeper cognitive level. Students are encouraged to not only understand concepts but also to reflect on their meaning, relate them to prior knowledge, and apply them in new contexts. This process supports the development of durable and transferable knowledge, which explains the substantial improvement observed in learning outcomes. The statistical findings of this study, particularly the significant increase in posttest scores, indicate that students experienced not just surface-level learning gains but a transformation in their conceptual understanding (Mubarok et al., 2025a).

In addition, the effectiveness of this model is reinforced by its emphasis on contextual and authentic learning experiences. By integrating local issues of regional development in Jayapura City into project activities, students perceive learning as relevant to their real-life environment. This relevance increases intrinsic motivation and encourages deeper cognitive processing, both of which are critical factors in achieving meaningful learning outcomes (Ringgo Ayomi et al., 2025).

How does social interaction in PjBL enhance conceptual understanding

Social interaction within the Project-Based Learning (PjBL) process plays a crucial role in enhancing students' conceptual understanding. Through collaborative activities, students are not only exposed to diverse perspectives but

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are also required to articulate, defend, and refine their ideas during group discussions. This process encourages cognitive conflict, which is essential for conceptual change. When students encounter differing viewpoints from their peers, they are prompted to re-evaluate their initial understanding and reconstruct more accurate and comprehensive concepts.

From a theoretical perspective, this process aligns with Vygotsky's social constructivist theory, particularly the concept of the Zone of Proximal Development (ZPD). Learning occurs most effectively when students engage in interactions with peers who provide scaffolding, enabling them to achieve higher levels of understanding than they could independently (Mubarok et al., 2025b). In the context of this study, group-based project activities created opportunities for peer tutoring, shared problem-solving, and collective knowledge construction, all of which contributed to deeper learning.

Furthermore, social interaction in PjBL supports the development of metacognitive awareness. As students explain concepts to others and respond to questions or critiques, they become more aware of their own thinking processes. This reflective engagement helps students identify gaps in their understanding and refine their conceptual frameworks (Taufik et al., 2025). The improvement observed in students' posttest responses, particularly their ability to explain concepts using their own words and relate them to real-world contexts, indicates that such socially mediated learning processes were effective in strengthening conceptual understanding (Wulandari & Wibawa, 2025).

In addition, collaborative interaction fosters a supportive learning environment that enhances student engagement and motivation. When students work together toward a shared goal, they develop a sense of responsibility and ownership over the learning process. This increased engagement leads to more intensive cognitive processing, which ultimately contributes to deeper and more meaningful understanding of the subject matter.

Development of Contextual Learning Tools

Another important outcome of this study is the development of contextual learning tools, including lesson plans, student worksheets, and project-based assessment instruments grounded in the Project-Based Learning (PjBL) model integrated with the Deep Learning approach. These learning tools were designed by considering the heterogeneous characteristics of students at SMA Negeri 4 Jayapura City and the local potential that could be incorporated as project themes. Expert validation results indicated that the developed tools were appropriate for classroom implementation and aligned with the six stages of the PjBL syntax: determining essential questions, designing project plans, developing schedules, monitoring progress, testing results, and evaluating learning experiences (Lestari et al., 2025).

The development of contextual learning tools is a critical factor in the successful implementation of PjBL. Komariyah (2020) emphasized that projects in PjBL must be authentic and relevant to students' lives in order to promote active and meaningful learning (Komariyah et al., 2020). In this study, projects were designed to explore regional development issues in Jayapura City, such as analyzing local economic potential, mapping the distribution of public facilities, and identifying development challenges in peripheral areas (Mutaqin, 2025). Students collected data through field observations, interviews with local residents, and document analysis, which were then transformed into thematic maps and regional development proposals. These activities not only enhanced conceptual understanding but also fostered 21st-century skills, including critical thinking, collaboration, communication, and creativity (Bagas Hidayatullah et al., 2026).

Partner teachers at the school expressed positive responses to the developed learning tools. They reported that the structured worksheets and clear project guidelines facilitated the management of innovative learning practices that had previously been rarely implemented. This finding indicates that the learning tools benefited not only students but also contributed to teachers' professional development. With access to valid and tested learning tools, teachers are better equipped to sustain these best practices independently across other topics or to disseminate them among colleagues.

Changes in Students' Conceptual Understanding

Qualitative analysis of students' essay responses, observational data, and project outputs revealed substantial changes in students' conceptual understanding. At the pretest stage, most students were only able to define regional

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development concepts in a rote manner, relying heavily on textbook definitions. They experienced difficulties in providing concrete examples or explaining relationships among concepts. After participating in the learning intervention, students demonstrated improved ability to articulate concepts using their own words, illustrate ideas with phenomena from their local environment, and analyze factors influencing regional development in Papua.

These changes reflect the achievement of the *mindful* element of the Deep Learning approach, which emphasizes students' awareness of their own learning processes and understanding (Maelasari & Lusiana, 2025). Through reflective activities conducted at the end of each session, students were encouraged to consider what they had learned, how they learned it, and its relevance to their lives. This metacognitive awareness is essential for developing deep and durable understanding. Furthermore, collaborative project work enabled meaning negotiation and social knowledge construction, consistent with Vygotsky's constructivist theory, which highlights the importance of social interaction in cognitive development (Panjaitan et al., 2023).

Students' ability to connect regional development theories with the local context of Papua emerged as a significant indicator of learning success. They were able to identify how the central place theory proposed by Christaller (1966) explains the urban hierarchy in Jayapura, where the city center provides goods and services to surrounding areas (Sicha & Nailah Syirva, 2025). Students also critically examined development disparities between urban and inland regions and proposed development strategies aligned with Papua's geographical and socio-cultural characteristics. Such contextualized understanding is difficult to achieve through conventional lecture-based instruction that emphasizes memorization.

Theoretical and Practical Contributions

Theoretically, this study contributes to the development of geography learning models by integrating the Deep Learning approach and PjBL within a single, empirically tested framework. The findings enrich the literature on contextual geography education, particularly for regional development topics that are complex and multidimensional. This study also supports Ausubel's theory of meaningful learning and Vygotsky's social constructivism within the context of Indonesian secondary education (Mutaqin, 2025). Moreover, it addresses a previously identified research gap regarding the limited empirical evidence on integrating Deep Learning and PjBL in senior high school geography instruction, especially in eastern Indonesia.

Practically, this study produced learning tools that can be directly implemented by geography teachers at SMA Negeri 4 Jayapura City and potentially adapted by other schools with similar characteristics. Teachers gained hands-on experience in designing and implementing innovative learning strategies, thereby enhancing their pedagogical capacity. For students, the learning intervention not only improved academic achievement but also equipped them with critical thinking, collaboration, and problem-solving skills relevant to 21st-century life. For schools, this study provides a model of best practice aligned with the implementation of the Merdeka Curriculum, which emphasizes differentiated learning and the development of the Pancasila Student Profile.

Limitations and Directions for Future Research

This study has several limitations that should be acknowledged. First, the use of a one-group pretest-posttest design without a control group limits the ability to control for external factors influencing learning outcomes, such as maturation effects or learning experiences outside the intervention. Second, the study was conducted in a single school with a relatively small sample size (34 students), which necessitates caution in generalizing the findings. Third, the relatively short duration of the intervention (four meetings) may not be sufficient to capture long-term changes in conceptual understanding. Fourth, affective and psychomotor domains were not comprehensively assessed, as the primary focus was on cognitive learning outcomes.

Based on these limitations, future studies are recommended to employ experimental designs with control groups (pretest-posttest control group designs) to more rigorously examine instructional effectiveness. Further research should also involve schools with diverse characteristics to enhance the generalizability of findings. Longer research durations would allow for the examination of long-term retention of conceptual understanding. Additionally, future studies may integrate digital media or educational technologies to enrich learning experiences and enhance the effectiveness of PjBL, as suggested by Dewi & Rusilowati (2025), who utilized the Tour Builder application in

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geography learning (Dewi & Rusilowati, 2025). Measuring affective aspects, such as attitudes toward geography learning and learning motivation, is also recommended to obtain a more comprehensive understanding of instructional impacts.

CONCLUSION

This study concludes that the integration of the Deep Learning approach with the Project-Based Learning (PjBL) model is effective in significantly improving students' learning outcomes on Regional Development material at SMA Negeri 4 Jayapura City. The statistically significant increase in scores ($p < 0.05$), with the mean rising from 24.29 to 74.96, indicates not only quantitative improvement but also a meaningful transformation in students' conceptual understanding. The effectiveness of this model is attributed to its ability to combine active knowledge construction, contextual learning, and deep cognitive engagement. The Deep Learning component ensures that students engage in meaningful, reflective, and durable learning processes, while the PjBL model provides authentic learning experiences through real-world problem-solving. This integration enables students to connect abstract geographical concepts with real regional development issues, thereby strengthening understanding and retention. In addition, social interaction within the PjBL process plays a key role in enhancing conceptual understanding. Through collaboration, discussion, and knowledge negotiation, students are able to refine their ideas, resolve misconceptions, and construct more comprehensive understandings. This socially mediated learning process supports higher-order thinking and facilitates deeper conceptual change.

This study contributes to the field of geography education by providing a concise empirical validation of an integrated Deep Learning–based PjBL framework that is effective, contextual, and applicable in real classroom settings, particularly in the eastern Indonesian context. Practically, the findings offer important implications for teachers and schools. The developed learning tools lesson plans, student worksheets, and project-based assessments can be directly implemented to promote active, collaborative, and meaningful learning. Teachers are encouraged to integrate local contextual issues and collaborative project activities into their instruction to enhance student engagement and conceptual understanding. Thus, this study not only strengthens theoretical perspectives on meaningful and social learning but also provides a practical instructional model that can be adapted and scaled in similar educational contexts.

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