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The Effectiveness of Deep Learning-Based PjBL on Students' Reasoning Ability and Motivation in the Science Curriculum Analysis Course

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Abstract: *This study aims to identify the effectiveness of learning using Deep Learning-based PjBL on students' reasoning ability and motivation, specifically in the curriculum analysis course material. This course studies the concepts, components, and documentation of the curriculum, aiming for students, especially those in the Science Education study program at HKBP Nommensen University Medan, to be able to analyze the relationship between learning objectives, learning outcomes, materials, learning processes, concepts, assessment components, and student characteristics. The method used in this quantitative research is a quasi-experimental method with a posttest-only control group design approach. Hypothesis testing used the t-test and MANOVA test to determine the effectiveness of Deep Learning-based PjBL on students' reasoning ability and motivation in the Science curriculum analysis material. The results obtained in this study showed a significant result of 0.003 < 0.005 with a t-count value of 3.102 > t-table 2.005, indicating that students who received Deep Learning-based PjBL learning had better reasoning abilities compared to students who received conventional learning. Similarly, for a significant value of 0.047 < 0.05 with a t-count value = 2.030 > t-table = 2.005, it can be concluded that the effect of Deep Learning-based PjBL on learning motivation is in the medium category.*

Keywords: *PjBL Model, Deep Learning, Reasoning Ability, Motivation, Curriculum Analysis*

INTRODUCTION

The educational paradigm shift in the 21st century requires universities not only to produce graduates who have a mastery of knowledge but also those capable of critical thinking, reasoning, problem-solving, collaborating, and applying knowledge in complex situations. These demands are increasingly relevant in pre-service teacher education, including for students of the Science Education Study Program, because students are not only prepared to master the material but also as prospective educators who must be able to understand, analyze, evaluate, and develop curricula according to student needs and educational developments. In this context, learning in the Science Curriculum Analysis course needs to be directed at learning experiences that allow students to connect curriculum concepts with real problems in science learning.

The Science Curriculum Analysis course has characteristics that cannot be sufficiently learned through the activities of memorizing curriculum concepts, components, or documents. Students must be able to analyze the interrelationship between educational goals, learning outcomes, learning objectives, materials, learning processes, assessments, and student characteristics. In its implementation, students are also required to be able to read and analyze curriculum documents, identify learning problems, provide arguments for a curriculum policy, and design relevant alternative science learning. These characteristics align with the implementation of the Science Curriculum Analysis course, which includes the analysis of curriculum documents, Learning Outcomes, Learning Objectives, and the design of learning devices, and can be implemented through Project Based Learning (PjBL).

One of the important abilities that needs to be developed through the Science Curriculum Analysis course is reasoning ability. Reasoning ability is the student's ability to use information, concepts, evidence, and logical relationships to produce justifiable conclusions or decisions. In curriculum studies, this ability is needed when students must determine the suitability between learning outcomes and learning objectives, analyze the relationship of objectives with learning activities, determine assessment suitability, and provide academic reasons for a curricular decision. Students with good reasoning abilities do not merely know the curriculum content but are able to explain why a curriculum component is suitable or not and how to improve it based on logical evidence and argumentation.

These issues become increasingly important when higher education learning still has the potential to be oriented toward information delivery and reproductive task completion. Such learning patterns can cause students to understand concepts partially and have fewer opportunities to test knowledge through real problems. Research on PjBL shows that project-based learning can provide space for learners to develop higher-order thinking skills through problem-solving and project-completion activities. The study by Ismail et al. (2024), for instance, shows that the implementation of PjBL is related to the development of Higher Order Thinking Skills (HOTS). Research by Walihah et al. (2023) also indicates the effect of PjBL on students' higher-order thinking skills.

Besides cognitive abilities, the success of the learning process is also influenced by student learning motivation. Motivation determines the level of involvement, perseverance, attention, and willingness of students in completing learning tasks. Students who have high learning motivation tend to be more active in seeking information, participating in discussions, facing difficulties, and completing tasks independently. Conversely, low motivation can cause students to merely complete tasks as an obligation without deep intellectual involvement. Therefore, applying a learning model that can connect lecture materials with real experiences and provide opportunities for students to produce a product becomes important.

Several studies show that PjBL has the potential to increase learning motivation. Surya et al. (2022) found that PjBL can affect science learning motivation and outcomes, and learning motivation was even analyzed as one of the factors related to learning outcomes. The research of Supriyanto et al. (2024) also showed an increase in learning motivation after the implementation of PjBL in science learning. However, research results do not always show that an automatic increase in motivation occurs just because PjBL is implemented. Research by Dhitareka et al. (2025) on science learning showed that although motivation was in the good category, the implementation of PjBL had not produced a significant increase between learning cycles. These findings indicate that the effectiveness of PjBL on motivation is

very likely influenced by the quality of project design, student involvement, learning context, and accompanying pedagogical strategies.

In the development of Indonesian education, the concept of deep learning has become an approach that is increasingly gaining attention. In an educational context, deep learning does not refer to artificial intelligence technology but to a pedagogical approach that emphasizes mindful, meaningful, and joyful learning. The Deep Learning Academic Paper published by the Ministry of Primary and Secondary Education in 2025 positions deep learning as an approach directed at answering 21st-century learning needs, including strengthening higher-order thinking skills, applying knowledge in real-world contexts, and mindful, meaningful, and joyful learning. The development of research on deep learning in Indonesia also increased significantly in 2025, especially after the concept gained more attention in national education policy.

The integration of deep learning-based PjBL has stronger potential compared to conventional PjBL implementation. PjBL provides an activity structure in the form of projects, while deep learning provides a pedagogical orientation so that projects do not merely produce products but also generate the process of understanding, applying, and reflecting on knowledge. Thus, projects in learning are not solely evaluated based on the final product but also based on the thinking process, argumentation quality, ability to connect concepts, decision-making, collaboration, and student reflection. The integration of both can create learning experiences that are more authentic and relevant to the characteristics of pre-service teacher education.

Empirically, recent research has started to show a relationship between the deep learning approach and the development of thinking skills and motivation. Nevertheless, there is a research gap that needs further study. So far, PjBL research has mostly focused on learning outcomes, HOTS, critical thinking skills, creativity, or motivation in primary and secondary school students. Meanwhile, research specifically testing the effectiveness of deep learning-based PjBL on the reasoning ability and motivation of pre-service science teacher students, especially in the Science Curriculum Analysis course, is still limited.

This gap is increasingly relevant because pre-service teacher students need to be prepared to face curriculum changes and dynamics. Studies on education students show that students still face challenges in understanding deep learning concepts and adapting to changes in curriculum approaches, as seen in Khairina et al. (2025). Based on this description, the implementation of deep learning-based PjBL in the Science Curriculum Analysis course is seen as having strong relevance to creating active, contextual, reflective, and student-competency-oriented learning. Projects designed based on real curriculum problems can encourage students to conduct document analysis, identify problems, seek and evaluate information, construct arguments, produce solutions, and reflect on learning outcomes. Theoretically, this process can stimulate reasoning skills while increasing learning motivation because students gain more meaningful learning experiences that have a direct connection to the profession they will pursue.

LITERATURE REVIEW

Project Based Learning (PjBL)

Project Based Learning (PjBL) is a learning model that places students as active learners through project completion activities that stem from authentic problems or questions. In PjBL, the learning process is not only directed at mastering materials but also at students' abilities to identify problems, plan activities, collect and analyze information, produce products, present results, and reflect on the learning process. These characteristics make PjBL relevant for learning oriented towards higher-order thinking skills.

A systematic review by Loyens et al. (2023) shows that problem- and project-

based learning environments possess characteristics that support the development of higher-order thinking, critical thinking, and critical-analytic thinking. The activities of facing problems, collaborating, and producing solutions are essential components that enable students to develop higher-order thinking processes.

The research by Hikmawati et al. regarding pre-service physics teacher students also shows the relevance of PjBL in learning for curriculum analysis courses. The study specifically involved Physics Education students taking a physics curriculum review course and tested the effect of PjBL on higher-order thinking skills. These findings provide a foundation that PjBL is suitable for use in courses that require students to conduct curriculum analysis.

Deep Learning

The term deep learning in this study needs to be distinguished from deep learning in the field of artificial intelligence. The deep learning referred to is deep learning pedagogy, which is a learning approach that emphasizes deep understanding, knowledge application in real contexts, and reflection on learning experiences.

In the context of Indonesian education, Deep Learning is developed with mindful, meaningful, and joyful principles. The learning process is directed so that students do not just receive information but understand concepts deeply, apply knowledge in relevant contexts, and reflect on both the process and learning outcomes. Anwar and Sodik (2025) explained that learning experiences in Deep Learning can be built through three main processes, namely understanding, applying, and reflecting.

The Deep Learning Academic Paper published by the Ministry of Primary and Secondary Education in 2025 positions Deep Learning as an approach aimed at facing 21st-century learning needs, including strengthening higher-order thinking skills and the ability to apply knowledge in real-life contexts.

A systematic review by Ratri et al. regarding Deep Learning in Indonesia also shows that the concept is related to meaningful, mindful, and joyful learning and requires authentic assessment and a supportive learning environment. This shows that Deep Learning is not just a teaching technique but an approach that affects the overall learning design.

Student Reasoning Ability

In Science Curriculum Analysis learning, reasoning ability is needed because students cannot simply know the contents of the curriculum. Students need to determine the relationship between various curriculum components and provide academic reasons for the analysis results they produce. These indicators align with the characteristics of higher-order thinking that develop through project-based learning environments. Loyens et al. (2023) indicated that PjBL can provide an environment allowing students to engage in analytical and higher-order thinking processes through problems and collaborative activities.

Research by Darussyamsu et al. (2024) also provided empirical support that PjBL activities can improve the ability of pre-service teacher students in understanding problems, conducting analysis, providing logical reasons, and generating solutions. Thus, Deep Learning-based PjBL theoretically has the potential to improve reasoning ability because students get the opportunity to perform a gradual thinking process, starting from understanding problems, collecting evidence, analyzing relationships between components, making decisions, to reflecting.

Student Learning Motivation

PjBL has the potential to increase motivation because students have the opportunity to work on concrete projects and produce observable products. This process provides a more active learning experience compared to learning that is solely centered on lectures. Research by Hasan et al. (2024) on students at Universitas Negeri Medan showed that the implementation of PjBL provided differences in student learning motivation

between the experimental and control groups. The experimental group's motivation score also increased from the initial to the final measurement. These findings are relevant to the research to be conducted because both place university students as research subjects.

Research Gap and Novelty

Based on previous research, there are several gaps that form the basis of this study. First, PjBL research in higher education has extensively examined critical thinking skills, HOTS, learning outcomes, and motivation, but studies specifically measuring student reasoning abilities in the context of Science Curriculum Analysis are still limited. Second, research on Deep Learning in Indonesia has developed rapidly, especially since 2025, but most research is still conceptual, literature reviews, or implementation in school learning. Ratri et al. (2026), for instance, showed that Deep Learning research in Indonesia still faces issues of implementation consistency, pedagogical readiness, and authentic assessment. Third, the research by Taufik et al. (2025) has examined Deep Learning-based PjBL, but its result focus was on scientific and critical thinking skills. Research that tests its effect on the reasoning ability and motivation of pre-service science teacher students simultaneously still has room for development. Fourth, research regarding PjBL on pre-service teacher students taking curriculum courses has yielded positive results on HOTS, but its integration with Deep Learning principles has not been widely studied. The research by Hikmawati et al. provides a very close context because it involves pre-service physics teacher students in a curriculum review course. Thus, the novelty of this research lies in the integration of PjBL with Deep Learning principles (mindful, meaningful, and joyful) in the learning of Science Curriculum Analysis, as well as testing its effectiveness on two outcomes simultaneously, namely the reasoning ability and motivation of pre-service science teacher students.

METHODS

The research conducted is quantitative research that collects data using research instruments and is analyzed in quantitative descriptive statistics by evaluating the tested hypotheses. The research design uses a quasi-experimental method with a posttest-only control group design approach. In the design, there are two research groups, namely the experimental group and the control group. The experimental group was given the PjBL model treatment with a Deep Learning approach, while the control group received learning using conventional learning methods. Hypothesis testing was conducted using the t-test to see if the data were normally distributed and homogeneous; the MANOVA (Multivariate Analysis of Variance) test to determine whether there is a significant effect on several variables occurring simultaneously between two dependent variables with one independent variable; and effect size (Cohen's D) to see how great the effectiveness of Deep Learning-based PjBL is on the reasoning ability and motivation of students in the science curriculum analysis material.

$$ES = \frac{\bar{\bar{x}}_{\bar{e}} - \bar{x}_c}{SD_{Pooled}}$$

RESULTS AND DISCUSSION

The trial results conducted showed an r-count of 0.609 and an r-table of 0.444. When compared, r-count on the Product Moment r criteria and significance level α = 0.05 yields r-count > r-table or 0.609 > 0.444, with n = 20, which is considered valid. All questions will be used as research instruments to measure student reasoning ability and motivation in the curriculum analysis material. For the instrument reliability test, it shows the following results:

On the analysis data of student reasoning ability and motivation questionnaire, the mean and standard deviation tests for the control and experimental classes show the following:

Table 1. the mean and standard deviation tests for the control and experimental

Data	Posttest	Rata-Rata	Standar Deviasi
Data untuk uji tes	Eksperimen	72,2500	17,4772
	Kontrol	58,5714	15,4595
Data untuk uji motivasi	Eksperimen	104,1429	10,5047
	Kontrol	98,8571	8,9182

Table 2. The posttest result data of student reasoning ability using Deep Learning-based PjBL in the Science Curriculum

Posttest	Jumlah Data	Rata-Rata	Standar Deviasi	L Hitung	L Tabel
Eksperimen	28	72,2500	17,4772	0,0932	0,1674
Kontrol	28	58,5714	15,4595	0,0806	0,1674

Table 3. the posttest result data of student learning motivation using Deep Learning-based PjBL in the Science Curriculum Analysis material

Posttest	Jumlah Data	Rata-Rata	Standar Deviasi	L Hitung	L Tabel
Eksperimen	28	104,1429	10,5047	0,1461	0,1674
Kontrol	28	98,5871	8,9182	0,0650	0,1674

Based on the prerequisite test, the data groups are proven to meet the requirements, allowing them to proceed using the independent two-sample t-test. This is done to determine the effectiveness of Deep

Table 4. t-Test: Two-Sample Assuming Equal Variances

	X1 (Eksperimen)	X2 (Kontrol)
Mean	72,250	58,571
Variance	305,454	238,995
Observations	28	28
Pooled Variance	272,224	
Hypothesized Mean Difference	0	
df	54	
t Stat	**3,102**	
P(T<=t) one-tail	0,002	
t Critical one-tail	1,674	
P(T<=t) two-tail	**0,003**	
t Critical two-tail	**2,005**	

Table 5. t-Test: Two-Sample Assuming Equal Variances

	X1 (Eksperimen)	X2 (Kontrol)
Mean	104,143	98,857
Variance	110,349	79,534
Observations	28	28
Pooled Variance	94,942	
Hypothesized Mean Difference	0	
df	54	
t Stat	**2,030**	
P(T<=t) one-tail	0,024	
t Critical one-tail	1,674	
P(T<=t) two-tail	**0,047**	
t Critical two-tail	**2,005**	

This difference is caused by the different learning treatments, namely the use of the PjBL model with a Deep Learning approach compared to conventional learning. Thus, Deep Learning-based PjBL has a significant effect on the reasoning ability and motivation of students in the science curriculum analysis material. The multivariate test explains that the results of the significant treatment

obtained a value of 0.001, where 0.001 < 0.05, according to the criteria that H0 is rejected and Ha is accepted, meaning there is a simultaneous significant difference in reasoning ability and student learning motivation between the experimental and control classes.

Table 6. Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.993	3905.645[b]	2.000	53.000	.000
	Wilks' Lambda	.007	3905.645[b]	2.000	53.000	.000
	Hotelling's Trace	147.383	3905.645[b]	2.000	53.000	.000
	Roy's Largest Root	147.383	3905.645[b]	2.000	53.000	.000
Posttest	Pillai's Trace	.232	8.008[b]	2.000	53.000	.001
	Wilks' Lambda	.768	8.008[b]	2.000	53.000	.001
	Hotelling's Trace	.302	8.008[b]	2.000	53.000	.001
	Roy's Largest Root	.302	8.008[b]	2.000	53.000	.001

a. Design: Intercept + Kelas

b. Exact statistic

Table 7. MANOVA Results for the Effect of Deep Learning-Based PjBL on Students' Reasoning Ability and Learning Motivation

	Mean	SD	n
X1 Eksperimen	72,250	17,477	28
X2 Kontrol	58,571	15,459	28
M1-M2	13,679		
Pooled SD	16,499		
Cohen'S D	0,829		

It can be concluded that the Project Based Learning model with a Deep Learning approach influences the reasoning ability on quadratic function material at SMK Pencawan Medan by 0.829, which is a large criteria.

Table 8. Effect Size (Cohen's D) Results for the Effect of Deep Learning-Based PjBL on Students' Reasoning Ability and Learning Motivation

	Mean	SD	n
X1 Eksperimen	104,143	10,505	28
X2 Kontrol	98,857	8,918	28
M1-M2	5,286		
Pooled SD	9,744		
Cohen'S D	0,542		

It can be concluded that the Project Based Learning model with a Deep Learning approach influences student learning motivation on curriculum analysis material by 0.542, which is a medium criteria. The research results indicate that the effectiveness of Deep Learning-based PjBL influences students' reasoning ability. This can be seen from the t-test results which obtained a significance value of 0.003 < 0.05 with a t-count value = 3.102 > t-table = 2.005. Additionally, the Effect Size (Cohen's D) value of 0.829 shows that the given influence is included in the large category. These results indicate that students who receive Deep Learning-based PjBL learning have better reasoning abilities compared to students who receive conventional learning. In the learning motivation variable, the research results show a significance value of 0.047 < 0.05 with a t-count value = 2.030 > t-table = 2.005. The Effect Size (Cohen's D) value of 0.542 indicates that the effect of Deep Learning-based PjBL on learning motivation is in the medium category. These results indicate that the application of learning that actively involves students can provide a positive influence on student learning motivation.

CONCLUSION

Therefore, the effectiveness of deep learning-based PjBL has a significant effect with an effect size value of 0.829, while the effect on learning motivation has a value of 0.542. These results indicate that learning which actively involves students through projects and meaningful learning experiences can help students solve problems in the science curriculum analysis course.

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