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Cultivating Classroom-Ready Skills: How Micro-Project Based Learning Foster Analytical Capacities in Pre-service Elementary Teachers

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Abstract

This study aims to evaluate the effectiveness of Micro-project Based Learning (M-PjBL) in improving the analytical skills of prospective elementary school teachers in the Basic Concepts of Science course. A pre-experimental research design with a single-group pretest-posttest was implemented on 51 prospective teachers. The mPjBL model focuses on intensive, small-scale investigations to stimulate higher-order thinking. Data were collected using a validated analytical ability test based on the revised version of Bloom's Taxonomy (differentiating, organizing, and attributing) and analyzed using paired-sample t-tests and Normalized Gain (N-gain) scores. The results of the paired samples t-test show a significant increase in students' analytical abilities after the implementation of M-PjBL, with a t value = 8.146 (df = 50, $p < 0.001$). This increase in analytical ability is also reflected in the N-gain, which shows an average percentage increase of 26.98%. According to Hake's criteria, a g-value below 0.30 falls into the low-gain category. Therefore, while the M-PjBL learning model stimulated an upward trend in students' analytical capacities, the overall improvement remains at a low-to-medium level. This modest gain indicates that while the model provides a foundation for development, certain pedagogical constraints may have limited its maximum effectiveness. This study offers an innovative approach by modifying the Project-Based Learning (PjBL) model into Micro-project Based Learning (M-PjBL), which reduces the complexity of large projects into more focused on micro units. Unlike the traditional PjBL approach which requires more resources and time-consuming, M-PjBL allows students to focus more on in-depth analysis of specific scientific phenomena, without sacrificing scientific integrity. This study is also the first to measure the effectiveness of M-PjBL in improving the analytical skills of prospective elementary school teachers through specific indicators developed based on the revised version of Bloom's Taxonomy, namely differentiating, organizing, and attributing.

Keywords: Micro-Project Based Learning; Pre-service Elementary Teacher; Analytical Thinking; Science Course

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1. Introduction

In recent decades, science education has increasingly emphasized the development of higher-order thinking skills (HOTS) as a core competency for future teachers, particularly in response to global demands for scientific literacy, problem-solving, and evidence-based reasoning in the 21st century. International education frameworks highlighted that teachers were no longer expected to merely transmit scientific facts, but to facilitate students' ability on phenomena analysis, interpret data, and apply scientific reasoning to real-world contexts. However, numerous studies indicate that pre-service teachers across different educational systems still struggle to develop robust analytical reasoning skills during their initial teacher educations.

Science education in elementary schools requires educators who do not only master the content but also possess in-depth scientific literacy to analyze complex phenomena into explanations which can be understood by young learners. However, the reality in teacher training institutions (LPTK) demonstrates a chronic disconnect between the theory learned in college and practice in the field (Nikmah et al., 2020; Purwanti, 2020; Sari et al., 2025). Pre-service elementary school teachers often fall into the trap of rote learning, lacking the ability to deconstruct scientific principles. The main challenge is poor analytical skills, a crucial component of Higher-Order Thinking Skills (HOTS) (Haris et

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al., 2025; Özpir et al., 2025; Zohar & Dori, 2003) which enables prospective teachers to distinguish variables, organize data, and connect science concepts to real-world contexts. Analytical skills, often referred to as C4 skills, which are essential for aspiring elementary school teachers, especially in the field of science (Atmojo et al., 2017; Liu et al., 2025; Luchinskaya, 2025; Nurussaniah et al., 2025). This skill enables teachers to logically and systematically solve complex problems by breaking down the huge problems into smaller, more manageable parts.

Analytical skills are vital for prospective elementary school teachers since they are responsible for laying the foundation of students' logical and scientific thinking. Empirical evidence shows that many prospective elementary school teachers still demonstrate insufficient analytical competence, as mentioned by Yusro et al. (2025) reported that 62% of prospective teachers exhibited only moderate levels of analytical skills. Without strong analytical skills, prospective teachers risk bringing and spreading scientific misconceptions into the classroom (Hasnawati et al., 2022). Although various project-based learning (PjBL) models have been widely researched, their implementations in Basic Science Concepts courses often faces constraints such as rigid time management, limited laboratory equipment, and material coverage that is too broad (Bell, 2010). This often results in projects being carried out that only focus on the end result (product) without providing enough space for students to train their analytical cognitive processes.

To bridge this gap, this study introduces Micro-project Based Learning (M-PjBL). Unlike traditional PjBL, which requires extensive time and resources, M-PjBL emphasizes small-scale, focused, intensive, and iterative investigations (Chen et al., 2025; Tian et al., 2023; Zhang et al., 2018). Through M-PjBL, project complexity is reduced to micro-units that allow students to conduct in-depth analysis on a specific phenomenon (for example, variable analysis of water capillarity or changes in kinetic energy in a simple device). From a cognitive perspective, reducing project scope into micro-level investigations allows learners to focus on fewer variables at a time, thereby lowering extraneous cognitive load and enabling deeper analytical processing (Sweller, 1988; Sweller et al., 2011). This inquiry structure supports the development of C4-level skills by encouraging students to systematically differentiate variables, organize empirical observations, and construct causal explanations based on evidence, which are core components of analytical thinking in science learning (Zohar & Dori, 2003). Thus, M-PjBL is theoretically positioned as an instructional design that aligns closely with the cognitive demands of analytical thinking in science learning. This "micro" approach is designed to encourage students to zoom in on specific scientific details that are often in larger projects, thereby sharpening analytical skills in a more focused and measurable manner.

Research on PjBL has been widely documented, but l previous studies that which specifically evaluates effectiveness of micro-scale projects in improving specific indicators of analytical skills (such as differentiating, organizing, and attributing) in prospective elementary school teachers is still very limited. (Yusro et al., 2025). The novelty of this research lies in the modification of the project structure to be more efficient while maintaining the integrity of scientific inquiry. Therefore, this study aims to evaluate the impact of M-PjBL on the analytical skills of prospective elementary school teachers in the Basic Concepts of Science course.

This study contributes to the field of science education in three significant ways. First, it extends the theoretical discussion of project-based learning by conceptualizing Micro-project Based Learning as a focused instructional scaffold for developing analytical (C4) cognitive skills. Second, it provides empirical evidence on the effectiveness of M-PjBL in improving analytical skills among prospective elementary school teachers using a pretest–posttest design. Third, this study offers a practical learning model that addresses common constraints in Basic Science Concepts courses, such as limited instructional time and laboratory resources.

A pretest–posttest design was employed to capture changes in analytical skills attributable to the implementation of M-PjBL, allowing for a direct comparison of students' cognitive performance before and after the intervention. Through a pretest and posttest design, this study will answer key questions regarding:

(1) Is there a significant difference in the analytical abilities of prospective elementary school teachers regarding basic science concepts before and after the implementation of Micro-project Based Learning?
(2) To what extent is the effectiveness of implementing M-PjBL in improving the analytical skills of prospective elementary school teachers in the Basic Science Concepts course?

2. Literature Review

2.1. Analytical Skills in Science Teacher Education

Analytical skills are a component of higher-order thinking that enables students to deconstruct information, identify relationships among concepts, distinguish between relevant and irrelevant variables, organize evidence, and construct

logical explanations. In Bloom's revised taxonomy, analytical skills are generally associated with the cognitive level of analyzing, which includes differentiating, organizing, and attributing (Suyatman et al., 2021). These skills are essential in science learning because scientific understanding requires learners to examine phenomena, interpret data, identify causal relationships, and explain concepts based on evidence rather than memorization.

For prospective elementary school teachers, analytical skills play a strategic role in guiding young learners to develop early scientific reasoning. Elementary science teachers must be able to simplify complex scientific concepts without compromising conceptual accuracy. This requires the ability to analyze scientific phenomena, select appropriate explanations, design meaningful learning activities, and anticipate potential misconceptions. Therefore, developing analytical skills during teacher education is vital not only for improving students' academic achievement but also for strengthening their future pedagogical competence.

In the context of Basic Science Concepts courses, analytical skills are closely related to a student's ability to observe scientific phenomena, identify variables, compare patterns, interpret experimental results, and draw evidence-based conclusions (Suyatman et al., 2021). These abilities are particularly important because prospective teachers often need to transform abstract scientific concepts into concrete learning experiences for elementary school students. Without adequate analytical skills, prospective teachers may understand science only at the level of factual knowledge and struggle to explain scientific processes systematically. Furthermore, pedagogical research emphasizes that analytical thinking involves the systematic breakdown of complex systems into their constituent parts to discern how individual variables interact to influence overall functionality (Bilgin & Kala, 2022). By engaging in this process, educators can cultivate a scientific mindset that prioritizes structured reasoning over rote memorization (Küçükaydın & Ayaz, 2024). Moreover, cultivating these competencies empowers pre-service teachers to better integrate disparate scientific concepts, addressing a common deficiency where learners struggle to synthesize knowledge to resolve complex problems (Parmin & Savitri, 2022). Consequently, integrating inquiry-based approaches into teacher training fosters the critical ability to evaluate causal mechanisms and evidence, which is essential for translating rigorous scientific reasoning into effective classroom instruction (Bao & Koenig, 2019; Barnhart & van Es, 2015). This pedagogical shift is necessary because pre-service teachers must mirror the scientific inquiry processes—such as generating hypotheses, planning investigations, and analyzing data—that they are expected to facilitate in their own future classrooms (Akgul, 2006; Khan & Krell, 2019). By cultivating these inquiry-driven proficiencies, teacher education programs enable pre-service teachers to bridge the gap between abstract scientific understanding and the practical implementation of experimental design, hypothesis testing, and systematic data interpretation. Ultimately, this transformative process equips them with the pedagogical confidence to foster similar analytical rigor in elementary learners, thereby elevating the quality of science instruction and supporting the development of foundational scientific literacy.

2.2. Project-Based Learning and Analytical Skills

Project-Based Learning is a student-centered model that engages learners in investigating problems, designing solutions, and presenting findings (Zhang et al., 2024). By actively constructing understanding through practice, students meticulously dissect issues and weigh resolutions, fostering the cognitive faculties necessary for scientific inquiry (Zhang et al., 2024). This approach strengthens analytical thinking as students examine relationships between concepts, identify variables, evaluate evidence, and justify conclusions. Research consistently indicates statistically significant correlations between project-oriented instructional models and the development of analytical abilities (Perminova et al., 2025).

Effective PjBL implementation can face challenges, including resource demands and the risk that students prioritize final products over analytical processes. Without sufficient scaffolding such as structured rubrics or reflective feedback loops—students may struggle to analyze variables, organize observations, or construct evidence-based explanations. Instructional designers can mitigate these constraints by emphasizing the systematic evaluation of complex, real-world data rather than focusing solely on the final artifact. Implementing such structure significantly improves analytical performance, demonstrating the model's effectiveness when properly guided.

Structured, project-oriented models are highly effective in cultivating analytical competence (Perminova et al., 2025). By requiring students to engage in rigorous scientific practices—such as formulating hypotheses, planning investigations, and interpreting empirical data—these models foster the structured reasoning and critical thinking essential for prospective teachers (Bao & Koenig, 2019; Loyens et al., 2023). Furthermore, focused scaffolding ensures that students prioritize systematic inquiry, reinforcing the cognitive habits necessary for valid scientific reasoning (Suryanti et al., 2024).

Developing these analytical competencies is particularly vital for pre-service educators, as it enables them to bridge the gap between abstract scientific understanding and the practical, evidence-based instruction required to support foundational literacy in elementary learners (Barnhart & van Es, 2015). By internalizing these inquiry processes, prospective teachers are better equipped to model the structured thinking they must facilitate in their future classrooms, ultimately elevating the quality of science instruction (Akgul, 2006).

2.3. Micro Project-Based Learning as an Instructional Scaffold

Micro Project-Based Learning adapts project-based learning by organizing activities into smaller, more focused, and manageable units. Instead of requiring students to complete a single, large-scale project, M-PjBL directs them to investigate specific scientific phenomena through limited but intensive tasks.

This approach retains the essential characteristics of traditional PjBL including inquiry, experimentation, collaboration, reflection, and presentation while reducing overall project complexity. By narrowing the scope, M-PjBL enables students to engage more deeply with scientific processes, ensuring that instruction remains both effective and manageable. Moreover, incorporating structured checkpoints within these smaller units allows instructors to monitor student progress more effectively, ensuring that scaffolding is provided precisely when needed to reduce cognitive load (Dag & Durdu, 2017). This iterative cycle of design, implementation, and critical reflection fosters an environment where pre-service teachers move beyond superficial performance to achieve a deeper understanding of pedagogical and scientific inquiry. Furthermore, the use of multiple representations such as verbal, graphical, and mathematical models within these targeted projects allows pre-service teachers to refine their inference-making and evaluation skills (Danday & Monterola, 2019; Yunus et al., 2021). By providing pre-service teachers with repeated opportunities to experience these pedagogical frameworks firsthand, M-PjBL mirrors the collaborative inquiry necessary for developing professional pedagogical content knowledge (Dragnić-Cindrić & Anderson, 2025; Yang et al., 2018). Specifically, integrating these micro-units into teacher preparation facilitates a more nuanced understanding of scientific inquiry, as pre-service teachers learn to navigate the design, execution, and iterative assessment of student-led investigations. This hands-on experience not only demystifies the inquiry process but also provides a structured environment for them to cultivate the pedagogical foresight required to anticipate learner difficulties, tailor scaffolding interventions, and foster a culture of evidence-based reasoning within elementary science classrooms (Akgul, 2006).

2.4. The Relationship between M-PjBL and Analytical Skills

The relationship between M-PjBL and analytical proficiency is manifested through the cognitive engagement required by micro-project tasks. Within this framework, students are tasked with problem identification, phenomenological observation, variable determination, data acquisition, synthesis of findings, and the conceptualization of inter-relational dynamics (Suyatman et al., 2021). Such activities are intrinsically linked to core indicators of analytical cognition, specifically the capacities for differentiation, organization, and attribution.

Initially, M-PjBL facilitates the capacity to differentiate by necessitating the identification of variables or information pertinent to the investigation. For instance, when analyzing phenomena such as water capillarity or kinetic energy shifts within a mechanical apparatus, students must discern influential factors from extraneous details. Furthermore, the model cultivates organizational competence, as learners are compelled to structure observations, data, and evidence logically. Finally, M-PjBL promotes attributional skills, requiring students to articulate causal mechanisms and integrate their findings with fundamental scientific principles.

Moreover, M-PjBL mandates post-project reflection, an essential practice that allows students to critically assess their reasoning, rectify interpretive inaccuracies, and consolidate conceptual understanding. This reflective trajectory is particularly vital for prospective teachers; it shifts their perspective from that of a learner to that of a future practitioner capable of evaluating instructional efficacy and scaffolding student cognition.

Given these theoretical underpinnings, M-PjBL constitutes a robust instructional model for enhancing analytical proficiency within Basic Science Concepts curricula. Its streamlined, inquiry-centric design enables students to engage substantively with scientific phenomena while incrementally cultivating the cognitive processes requisite for analytical thought. Consequently, M-PjBL offers a pertinent pedagogical framework for preparing prospective elementary educators to analyze scientific concepts and translate them into effective instructional practices. This shift aligns with contemporary trends in science education that prioritize problem-solving and evidence-based reasoning to meet the exigencies of 21st-century curricula (Bayani et al., 2025). Although this focused methodology alleviates the time-related constraints typical of traditional, comprehensive PBL implementations (Tian et al., 2023), it remains

instrumental in fostering the hypothesis-driven reasoning and scientific practices essential for rigorous academic inquiry (Loyens et al., 2023; Pujianto et al., 2024). Specifically, this structural design facilitates the disciplined application of the scientific method, empowering students to generate hypotheses and interpret empirical data with enhanced precision (Suryanti et al., 2024). By instilling these cognitive habits, M-PjBL functions as a catalyst for deeper scientific literacy, ensuring that future educators are adept at facilitating analogous inquiry-based explorations for their students (Novallyan, 2025). Furthermore, the model's emphasis on systematic inquiry harmonizes with constructivist theories, which posit that active engagement and social interaction are primary drivers in developing sophisticated mental models (Nigussie et al., 2025; Wang et al., 2025). Aligning with these theoretical foundations, recent scholarly discourse underscores that embedding structured inquiry within a problem-based framework significantly improves the critical thinking and analytical competence of prospective science teachers (Muhali & Asy'ari, 2026). This convergence underscores the model's potential to facilitate the necessary transition from teacher-centered paradigms toward student-led, inquiry-based frameworks that emphasize 21st-century competencies (Hujjatusnaini et al., 2022). Furthermore, immersion in such environments allows pre-service teachers to accrue essential pedagogical content knowledge while simultaneously enhancing their decision-making capabilities and professional self-efficacy (Dragnić-Cindrić & Anderson, 2025; Tsybulsky & Muchnik-Rozanov, 2021). Through active participation, prospective teachers transcend passive learning, confronting traditional instructional paradigms and subsequently recalibrating their pedagogical beliefs and classroom management strategies (Ertmer et al., 2014; He & Qi, 2022). By redirecting the focus toward collaborative, inquiry-driven research, this approach further strengthens students' problem-solving efficacy and fosters the scientific process skills integral to informed decision-making (Mahasneh & Alwan, 2018). By fostering an iterative culture of prototyping, reflection, and redesign, this methodological integration prepares educators to manage the complexities of modern scientific inquiry in the classroom, ensuring they possess the adaptive capacity to translate theoretical scientific understanding into responsive, student-centered pedagogical practice. Furthermore, by encouraging learners to develop deductive and inductive reasoning to resolve complex problems, the M-PjBL model empowers prospective teachers to cultivate similar critical competencies in their future classrooms, thereby bridging the gap between theoretical pedagogical training and the practical demands of facilitating inquiry-driven instruction (Loyens et al., 2023; Zhang et al., 2018).

3. Methods

3.1. Research Design

This study used a quantitative approach with a pre-experimental design (One-Group Pretest-Posttest Design) (Setyosari, 2013). This design was chosen to measure the effectiveness of the Micro-Project Based Learning (M-PjBL) intervention on students' analytical skills before and after treatment.

O_1 X O_2

Information:
O_1 : Pretest
X : Treatment M-PJBL
O_2 : Posttest

3.2. Participants and Research Setting

The subjects of this research were prospective elementary school teacher students who were programming in the Basic Concepts of Science course. The subjects of this study were pre service elementary school teachers programming in the Basic Science Concepts course. Classes were determined using cluster sampling, which utilizes pre-existing classes. This technique is commonly used by researchers because random sampling or randomization of structured classes in PGRI Madiun University is not possible (Setyosari, 2013). The participants of this study consisted of 51 pre-service elementary school teachers. All respondents were actively enrolled in the Basic Science Concepts course during the odd semester of the 2025/2026 academic year. This specific cohort was selected because the nature of the course inherently requires deep analytical capacities, making it highly relevant for evaluating the implementation of the Micro-project Based Learning (M-PjBL) model.

3.3. Instruments and Data Collection

The main instrument is an analytical ability test compiled based on the Marzano or Bloom Revised version (C4) indicators, which include: differentiating, organizing and attributing. Where differentiating means identifying the relevant/important parts of a science concept. Organizing is determining how elements work together in a system. Meanwhile, attributing is determining the point of view or bias behind the material presented. The instruments used in this study have been tested for validity (Expert Judgment/Pearson) and reliability (Cronbach's Alpha).

3.4. Data Analysis Technique

Data were processed using parametric statistical analysis (if the data were normally distributed) with SPPSS with the Paired Sample T-Test and N-Gain Score (Normalized Gain). The Paired Sample T-Test was conducted to determine whether there was a significant difference between the pretest and posttest scores. Meanwhile, the N-Gain Score (Normalized Gain) was used to determine the level of model effectiveness. The data were analyzed using parametric statistical methods (provided that the data were normally distributed). The N-Gain criteria were classified as follows: High ($g > 0.7$), Medium ($0.3 \leq g \leq 0.7$), and Low ($g < 0.3$).

4. Result and Discussion

4.1. Descriptive Statistics of Analytical Skills

This section presents the findings of the study based on the results of statistical data analysis. The data were analyzed using parametric statistical methods after meeting the assumption of normal distribution. The results are presented in the form of descriptive statistics, tables, and figures to provide a clear overview of students' performance before and after the intervention. As the findings reveal the descriptive statistics in Table 1 show a consistent increase in the analytical skills of prospective elementary school teachers using Micro-project Based Learning (M-PjBL). From 51 respondents, the average analytical skill score in the pretest was 74.51 (SD = 7.11) with a score range of 60–88, while in the posttest the average score increased to 81.57 (SD = 7.43) with a score range of 64–96. The increase in the average score of 7.06 points indicates analytical skills alteration into a higher level which then generalize for almost all respondents. Moreover, stable standard deviation between the pretest and posttest indicates that the increase occurred evenly and was not driven only by a small number of participants with extreme scores. Descriptively, these findings provide a strong initial indication of the effectiveness of M-PjBL implementation in improving students' analytical skills, which were then tested inferentially in the next stage of analysis.

Before conducting inferential statistical analysis to test the differences in analytical ability between pretest and post-test scores, statistical assumption tests were first conducted to ensure that the data met the requirements for using parametric tests. The assumption tests conducted in this study included a normality test to determine data distribution and a homogeneity of variance test to ensure uniformity of variance between measurements. Fulfilment of these two assumptions is an important basis for determining the feasibility of using the paired samples t-test in the subsequent analysis stages.

The results of the normality test (Table 2) indicate that the pretest and post-test scores of the analytical abilities of prospective elementary school teachers are normally distributed. Based on the Kolmogorov–Smirnov test, the significance value for the pretest was 0.136 and for the post-test was 0.063, both of which are greater than the 0.05 significance level. Furthermore, the Shapiro–Wilk test also showed shows consistent results, with a significance value of 0.126 for the pretest and 0.146 for the post-test. These findings indicate that there are no significant deviations in the data distribution, so the data meet the assumption of normality and are suitable for further analysis using parametric statistical tests.

4.2. Inferential Analysis

The results of the paired samples t-test in Table 3 shows that there is a significant difference between the pretest and post-test scores of the analytical abilities of prospective elementary school teachers after the implementation of Micro-project Based Learning (M-PjBL). The average difference in scores between the pretest and post-test was -7.06, indicating that the post-test score was higher than the pretest score. The test results produced a $t(50)$ value = -8.15 with a significance level of $p < 0.001$, so the difference that occurred was statistically significant. In addition, the 95%

confidence interval for the average difference was in the range of -8.80 to -5.32, all of which were below zero, confirming the consistent direction of increasing analytical abilities after the learning intervention. These findings indicate that the implementation of M-PjBL had a significant impact on towards improving students' analytical abilities.

Table 1. Description of analyitcal skills

Variable	Statistic	Statistic	Std. Error
Pre Test	Mean	74,510	0,995
	95% Confidence Interval for Mean (Lower Bound)	72,510	
	95% Confidence Interval for Mean (Upper Bound)	76,510	
	5% Trimmed Mean	74,520	
	Median	76,000	
	Variance	50,535	
	Std. Deviation	7,109	
	Minimum	60	
	Maximum	88	
	Range	28	
	Interquartile Range	12	
	Skewness	-0,007	0,333
	Kurtosis	-0,544	0,656
Pos Test	Mean	81,570	1,041
	95% Confidence Interval for Mean (Lower Bound)	79,480	
	95% Confidence Interval for Mean (Upper Bound)	83,660	
	5% Trimmed Mean	81,660	
	Median	80,000	
	Variance	55,250	
	Std. Deviation	7,433	
	Minimum	64	
	Maximum	96	
	Range	32	
	Interquartile Range	12	
	Skewness	-0,152	0,333
	Kurtosis	-0,386	0,656

Table 2. Test of Normality Analytical Thinking

Tests of Normality						
Variable	**Kolmogorov-Smirnov^a**			**Shapiro-Wilk**		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Pre Test	0,112	51	0,136	0,964	51	0,126
Pos Test	0,120	51	0,063	0,966	51	0,146

a. Lilliefors Significance Correction

Table 3. Paired Samples T Test

Bootstrap for Paired Samples Test							
					Bootstrap[a]		
		Mean	**Bias**	**Std. Error**	**Sig. (2-tailed)**	**95% Confidence Interval Lower**	**Upper**
Pair 1	Pre Test-Post Test	-7.058	-.001	.860	.001	-8.902	-5.529

The effect size calculation results in Table 4 using Cohen's d show that the implementation of Micro-project Based Learning (M-PjBL) has a significant impact towards improving the analytical skills of prospective elementary school teachers. Cohen's d value is -1.141 with a 95% confidence interval ranging from -1.491 to -0.784. This value indicates that the difference between the pretest and post-test scores is in the large effect category.

To complement the analysis of the difference test and effect size, this study uses used normalized gain (N-gain) to measure the level of increase in students' analytical abilities proportionally based on the initial score and the maximum score that can be achieved.

Table 4. Effect Size

Paired Samples Effect Sizes						
			Standardizer[a]	Point Estimate	95% Confidence Interval Lower	Upper
Pair 1	Pre Test – Post Test	Cohen's d	6.188	-1.141	-1.491	-.784
		Hedges' correction	6.235	-1.132	-1.480	-.778

a. The denominator used in estimating effect sizes.

Cohen's d uses the sample standard deviation of the mean difference

Hedges's correction uses the sample standard deviation of the mean difference, plus a correction factor

Table 5. Descriptive N-Gain

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
NGain_Skor	51	-0.25	0.88	0.2698	0.22079
NGain_Persen	51	-25.00	87.50	26.9833	22.07934
Valid N (listwise)	51				

Table 5 presents descriptive statistics of the normalized gain (N-gain) and N-gain values in percentage form on the analytical abilities of prospective elementary school teachers after the implementation of Micro-project Based Learning (M-PjBL). The N-gain value represents the level of improvement in students' analytical abilities that has been normalized against the maximum possible score, thus providing a proportional picture of learning improvement. Meanwhile, the N-gain percentage is a form of presentation of N-gain in percentage units to facilitate interpretation of the level of learning effectiveness.

This improvement in analytical skills is highly relevant for prospective elementary school teachers, as analytical skills are key to guiding students in understanding scientific concepts in a systematic and structured manner. Therefore, the results of this study indicate that the implementation of M-PjBL is not only effective in developing students' analytical skills but also has great potential to improve the quality of science teaching at the elementary level, which can have a positive impact on science learning in elementary schools.

4.3. Improved Analytical Skills

The results of the paired-samples t-test showed that students' analytical ability scores increased significantly from the pretest (M = 74.51) to the post-test (M = 81.57), with a p-value of less than 0.001. This finding indicates that the difference between the pretest and post-test scores was statistically significant and was unlikely to have occurred by chance. The improvement was also reflected in the N-gain result, which showed an average score of 0.27. Based on commonly used N-gain interpretation guidelines, this value indicates a low level of improvement. However, the result still suggests that the implementation of Micro Project-Based Learning (M-PjBL) contributed positively to students' analytical skills. The wide range of N-gain scores, from -0.25 to 0.88, indicates considerable variation among respondents, suggesting that students responded differently to the learning intervention.

These statistical findings are consistent with previous studies showing that project-based learning can support the development of students' analytical skills in various educational contexts (Sari et al., 2025; Wenzel, 2007; Yazici, 2020). In this study, the improvement was observed among prospective teachers, particularly in the context of science learning. Analytical thinking is essential for prospective elementary school teachers because they are expected to guide students in understanding scientific concepts systematically, evaluating evidence, and solving problems through logical reasoning. Previous studies have also emphasized that community-based, hands-on, and inquiry-oriented learning can strengthen analytical thinking among prospective teachers when supported by appropriate facilitation and structured learning tasks (Chumsukon & Ruangsan, 2021; Yang et al., 2018).

The effectiveness of M-PjBL may be explained by the characteristics of project-based learning itself. Project-based environments require students to identify problems, analyze information, evaluate possible solutions, and synthesize evidence to reach informed conclusions. Through these processes, students are trained to engage in higher-order thinking and reflective inquiry. The research-oriented and iterative nature of project-based learning also encourages students to move through cycles of investigation, experimentation, reflection, and revision, which can reinforce their analytical processes (Perminova et al., 2025; Suyatman et al., 2021). Similar findings have shown that structured project-based frameworks can improve learners' cognitive performance and problem-solving competence across different pedagogical settings (Faizah et al., 2022; Sumarni & Kadarwati, 2020; Suryandari et al., 2018).

4.4. Interpretation of N-gain Results

As a measure of proportional improvement, the N-gain percentage also showed a similar pattern, with an average value of 26.98%. Although several respondents showed substantial improvement, with the highest N-gain reaching 87.50%, others experienced a decline, with the lowest score reaching -25%. This variation indicates that the impact of M-PjBL was not uniform across all students. Differences in students' initial readiness, motivation, engagement, prior knowledge, and ability to complete micro-project tasks may have influenced the extent of improvement. The presence of a negative N-gain score (-25.00%) indicates that a small fraction of students experienced a decline in performance post-intervention. Pedagogically, this can be attributed to the cognitive overload and the novelty effect of M-PjBL. Unlike conventional lecture-based learning, M-PjBL demands high autonomy, time management, and complex problem-solving. Students who were deeply habituated to passive learning may have experienced adaptation anxiety or confusion during the fast-paced micro-projects, leading to suboptimal performance on the post-test.

The development of analytical thinking skills among prospective elementary school teachers is particularly important because these skills are closely related to the ability to foster higher-order thinking skills in future students. In science education, prospective teachers need to be able to analyze scientific phenomena, explain relationships between variables, interpret data, and guide students in drawing evidence-based conclusions. Therefore, strengthening analytical thinking during teacher education is an important foundation for improving the quality of future science instruction.

M-PjBL offers a relevant learning strategy because it breaks down complex projects into smaller and more manageable micro-units. This structure allows students to focus on specific scientific phenomena, such as water capillarity, changes in kinetic energy, or simple experimental mechanisms. By working on smaller project units, students can examine scientific details more carefully and develop analytical skills in a more measurable way (Chen et al., 2025; Ding et al., 2021; Prabhu et al., 2025; Tian et al., 2023). Compared with larger projects, micro-projects may reduce cognitive overload and provide clearer opportunities for students to observe, analyze, and reflect on specific concepts.

The findings of this study strengthen the argument that M-PjBL can be an effective pedagogical approach for improving students' analytical skills, particularly in science education at the higher education level. For prospective elementary school teachers, this improvement is highly relevant because analytical skills are needed to design meaningful learning activities, explain scientific concepts clearly, and help students develop systematic ways of thinking. Therefore, the implementation of M-PjBL is not only beneficial for improving students' current analytical abilities but also has the potential to enhance the quality of science teaching in elementary schools.

Nevertheless, the variation in N-gain results suggests that the implementation of M-PjBL still requires careful instructional design and facilitation. Some students may need more scaffolding, clearer project guidelines, or additional support in connecting project activities with scientific concepts. Future research should therefore examine the factors that influence students' different levels of improvement, such as motivation, prior knowledge, engagement, collaboration patterns, and the design of micro-project tasks. Further studies with larger samples and diverse institutional contexts are also needed to strengthen the generalizability of these findings.

Future research may also investigate the long-term effects of M-PjBL on prospective teachers' professional competencies. Longitudinal studies could examine whether the analytical gains developed through micro-project-based learning are retained and transferred into teaching practice. Such research would provide deeper insight into how hands-on, inquiry-based, and collaborative learning experiences contribute to the development of pedagogical content knowledge, instructional adaptability, and professional self-efficacy among novice teachers.

5. Conclusion

Based on the research results, there is a significant difference in the analytical abilities of prospective elementary school teachers regarding basic science concepts after the implementation of Micro-project Based Learning (M-PjBL). The paired samples t-test shows that the analytical ability scores increased significantly after the intervention ($p < 0.001$), answering the first research question. However, regarding its overall effectiveness, the N-gain analysis revealed a mean score of 0.27 (26.98%), placing the overall improvement within the low-to-medium category. The data also indicates a high variance in student outcomes; while the maximum individual N-gain reached a high of 0.88, one student's score conversely decreased to -0.25. In conclusion, while M-PjBL demonstrates a statistically significant positive trend in enhancing analytical skills, its practical effectiveness remains modest and varies widely among individuals. Therefore, further pedagogical refinements are needed to optimize and standardize its effectiveness for all participants.

References

Akgul, E. M. (2006). Teaching science in an inquiry-based learning environment: What it means for pre-service elementary science teachers. *Eurasia Journal of Mathematics, Science and Technology Education*, *2*(1), 71–81. https://doi.org/10.12973/ejmste/75439

Atmojo, I., Sunarno, W., & Ashadi, M. (2017). Profile of elementary school pre-service teacher based on high order thinking skills (HOTS) on natural science subject. In *Proceedings of the International Conference on Teacher Training and Education 2017 (ICTTE 2017)*.

Bao, L., & Koenig, K. (2019). Physics education research for 21st century learning. *Disciplinary and Interdisciplinary Science Education Research*, *1*(1), Article 2. https://doi.org/10.1186/s43031-019-0007-8

Barnhart, T., & van Es, E. (2015). Studying teacher noticing: Examining the relationship among pre-service science teachers' ability to attend, analyze and respond to student thinking. *Teaching and Teacher Education*, *45*, 83–93. https://doi.org/10.1016/j.tate.2014.09.005

Bayani, F., Rokhmat, J., Hakim, A., & Sukarso, A. (2025). Research trends in analytical thinking skills for science education: Insights, pedagogical approaches, and future directions. *International Journal of Ethnoscience and Technology in Education*, *2*(1), 129–157. https://doi.org/10.33394/ijete.v2i1.14142

Bell, S. (2010). Project-based learning for the 21st century: Skills for the future. *The Clearing House*, *83*(2), 39–43. https://doi.org/10.1080/00098650903505415

Bilgin, A. K., & Kala, N. (2022). Using case-based science scenarios to analyze preservice teachers' analytical thinking skills. *Journal of Theoretical Educational Science*, *15*(4), 867–883. https://doi.org/10.30831/akukeg.1095368

Chen, F., Mu, T., & Xue, Y. (2025). Research on intelligent technology empowering cross-disciplinary micro-project-based learning in middle school mathematics. *Digital transformation of regional education in China* (pp. 195–201).

Chumsukon, M., & Ruangsan, N. (2021). *Integration of RBL and CLR to enhance analytical thinking skills of pre-service teachers* (ED615142). ERIC. https://eric.ed.gov/?id=ED615142

Dag, F., & Durdu, L. (2017). Pre-service teachers' experiences and views on project-based learning processes. *International Education Studies*, *10*(7), 18–39. https://doi.org/10.5539/ies.v10n7p18

Danday, B. A., & Monterola, S. L. C. (2019). Effects of microteaching multiple-representation physics lesson study on pre-service teachers' critical thinking. *Journal of Baltic Science Education*, *18*(5), 692–707. https://doi.org/10.33225/jbse/19.18.692

Ding, D., Liu, G., Li, W., Liu, Y., Song, M., & Liu, N. (2021). Micro-project design and teaching practice based on sticky theory. In *Proceedings of the 5th International Conference on Education and Multimedia Technology*.

Dragnić-Cindrić, D., & Anderson, J. L. (2025). Developing pre-service teachers' pedagogical content knowledge: Lessons from a science methods class. *Education Sciences*, *15*(7), Article 860. https://doi.org/10.3390/educsci15070860

Ertmer, P. A., Schlosser, S., Clase, K., & Adedokun, O. (2014). The grand challenge: Helping teachers learn/teach cutting-edge science via a PBL approach. *Interdisciplinary Journal of Problem-Based Learning*, *8*(1), Article 1. https://doi.org/10.7771/1541-5015.1407

Faizah, N., Wijayati, N., & Widiatningrum, T. (2022). The influence of project based learning model on students' problem-solving competence in learning of acid-base. *Journal of Innovative Science Education*, *11*(3), 334–339. https://doi.org/10.15294/jise.v11i1.56478

Haris, A., Hasyim, M., Halim, A. D., & Ramadhan, I. (2025). The effectiveness of dynamic problem-solving strategy and innovative assessment tools to improve students' higher-order thinking skills. *Jurnal Pendidikan IPA Indonesia*, *14*(1), […]. https://doi.org/10.15294/jpii.v14i1.21433

Hasnawati, H., Syazali, M., & Widodo, A. (2022). Analysis of understanding science concepts for prospective elementary school teacher candidates. *Jurnal Penelitian Pendidikan IPA*, *8*(6), 2954–2960. https://doi.org/10.29303/jppipa.v8i6.2438

He, S., & Qi, C. (2022). The perceived impact of PBL program learning on shifting prospective teachers' beliefs: A case study in China. *Eurasia Journal of Mathematics, Science and Technology Education*, *18*(12), Article em2195. https://doi.org/10.29333/ejmste/12693

Hujjatusnaini, N., Corebima, A., Prawiro, S., & Gofur, A. (2022). The effect of blended project-based learning integrated with 21st-century skills on pre-service biology teachers' higher-order thinking skills. *Jurnal Pendidikan IPA Indonesia*, *11*(1), 104–118. https://doi.org/10.15294/jpii.v11i1.27148

Khan, S., & Krell, M. (2019). Scientific reasoning competencies: A case of preservice teacher education. *Canadian Journal of Science, Mathematics and Technology Education*, *19*(4), 446–464. https://doi.org/10.1007/s42330-019-00063-9

Liu, Y., Khalid, F., & Nasri, N. M. (2025). An investigation into college English teaching and 4C skills development: A case study of higher education in China. *International Journal of Learning, Teaching and Educational Research*, *24*(12), 451–473. https://doi.org/10.26803/ijlter.24.12.20

Loyens, S. M., Van Meerten, J. E., Schaap, L., & 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), Article 39. https://doi.org/10.1007/s10648-023-09757-x

Luchinskaya, D. (2025). Lecture content or analytical view? Perceptions of disciplinary knowledge and its use at work. *Studies in Higher Education*. Advance online publication. https://doi.org/10.1080/03075079.2025.2525452

Mahasneh, A. M., & Alwan, A. F. (2018). The effect of project-based learning on student teacher self-efficacy and achievement. *International Journal of Instruction*, *11*(3), 511–524. https://doi.org/10.12973/iji.2018.11335a

Muhali, M., & Asy'ari, M. (2026). Conceptual problem-based learning model: Promising intervention to enhance prospective science teachers' critical thinking skills. *Social Sciences & Humanities Open*, *13*, Article 102509. https://doi.org/10.1016/j.ssaho.2026.102509

Nigussie, K. T., Semahagn, B. K., Mersha, B. S., & Tamiru, A. B. (2025). Effects of paper-based problem scenarios on high school biological problem-solving skills and academic achievement. *Disciplinary and Interdisciplinary Science Education Research*, *7*(1), Article 21. https://doi.org/10.1186/s43031-025-00138-8

Nikmah, L., Maryani, I., & Purwanti, S. (2020). Analisis kemampuan berpikir tingkat tinggi mahasiswa PGSD Universitas Ahmad Dahlan pada pembelajaran IPA [Analysis of higher-order thinking skills of elementary teacher education students at Universitas Ahmad Dahlan in science learning]. *Natural: Jurnal Ilmiah Pendidikan IPA*, *7*(2), 40–51. https://doi.org/10.30738/natural.v7i2.8450

Novallyan, D. (2025). Optimization of teaching profession courses through project methods: Impact on biology education students. *International Journal of Education and Teaching Zone*, *4*(2), 126–143. https://doi.org/10.57092/ijetz.v4i2.431

Nurussaniah, N., Setyosari, P., Kuswandi, D., & Ulfa, S. (2025). Psychometric validation of an analytical skills test in physics using the Rasch model. *Journal of Baltic Science Education*, *24*(3), 522–537. https://eric.ed.gov/?id=EJ1477279

Özpir, H. C., Balcı Çömez, C., & Benzer, E. (2025). Scientific stories in the assessment of higher order thinking skills. *Cogent Education*, *12*(1), Article 2460226. https://doi.org/10.1080/2331186X.2025.2460226

Perminova, L., Shykhnenko, K. I., Yatsenko, V., Stets, H., & Valentieva, T. (2025). Methodological bases for the development of students' analytical abilities using research activities. *Seminars in Medical Writing and Education*.

Prabhu, R., Mendonca, S., Bellairu, P. K., & Shiri, N. D. (2025). Enhancing engineering education through mini project-based learning in computer integrated manufacturing laboratory: A student-centric approach. *Innovations in Education and Teaching International*, *62*(3), 971–985. https://doi.org/10.1080/14703297.2024.2362260

Pujianto, W. H., Degeng, I. N. S., Kamdi, W., & Degeng, M. D. K. (2024). The influence of project-based online learning and self-efficacy on students' critical thinking learning outcomes. *QALAMUNA: Jurnal Pendidikan, Sosial, dan Agama*, *16*(1), 745–756. https://doi.org/10.37680/qalamuna.v16i1.5095

Purwanti, S. (2020). Analisis kemampuan mahasiswa dalam menyelesaikan soal IPA tipe HOTS [Analysis of students' ability to solve HOTS-type science problems]. *JIPVA (Jurnal Pendidikan IPA Veteran)*, *4*(1), 93–101. https://doi.org/10.31331/jipva.v4i1.1102

Sari, S. A., Dewi, R. S., Kana, S., Kembaren, A., Hasibuan, H., & Talib, C. A. (2025). Integration of analytical chemistry flipbooks based on project-based learning in improving critical thinking skills and scientific literacy to support SDG-4. *Jurnal Pendidikan IPA Indonesia*, *14*(1), https://doi.org/10.15294/jpii.v14i1.21038

Setyosari, P. (2013). *Metode penelitian pendidikan dan pengembangan* [Educational research and development methods]. Kencana.

Sumarni, W., & Kadarwati, S. (2020). Ethno-STEM project-based learning: Its impact to critical and creative thinking skills. *Jurnal Pendidikan IPA Indonesia*, *9*(1), 11–21. https://doi.org/10.15294/jpii.v9i1.21754

Suryandari, K. C., Fatimah, S., Sajidan, S., Rahardjo, S. B., & Prasetyo, Z. K. (2018). Project-based science learning and pre-service teachers' science literacy skill and creative thinking. *Cakrawala Pendidikan*, *38*(3), […]. https://doi.org/10.21831/cp.v38i3.17229

Suryanti, S., Nursalim, M., Choirunnisa, N. L., & Yuliana, I. (2024). STEAM-project-based learning: A catalyst for elementary school students' scientific literacy skills. *European Journal of Educational Research*, *13*(1), 1–14. https://doi.org/10.12973/eu-jer.13.1.1

Suyatman, S., Saputro, S., Sunarno, W., & Sukarmin, S. (2021). Profile of student analytical thinking skills in the natural sciences by implementing problem-based learning model. *Journal of Educational, Cultural and Psychological Studies*, *23*, 89–111. https://doi.org/10.7358/ecps-2021-023-suya

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, *12*(2), 257–285. https://doi.org/10.1016/0364-0213(88)90023-7

Sweller, J., Ayres, P., & Kalyuga, S. (2011). *Cognitive load theory*. Springer. https://doi.org/10.1007/978-1-4419-8126-4

Tian, P., Sun, D., Han, R., & Fan, Y. (2023). Integrating micro project-based learning to improve conceptual understanding and crucial learning skills in chemistry. *Journal of Baltic Science Education*, *22*(1), 130–152. https://doi.org/10.33225/jbse/23.22.130

Tsybulsky, D., & Muchnik-Rozanov, Y. (2021). Project-based learning in science-teacher pedagogical practicum: The role of emotional experiences in building preservice teachers' competencies. *Disciplinary and Interdisciplinary Science Education Research*, *3*(1), Article 9. https://doi.org/10.1186/s43031-021-00037-8

Wang, C., Song, L., & Jiang, J. (2025). The impact of project-based learning on university physics education: Enhancing cognitive skills and core competencies. *Frontiers in Psychology*, *16*, Article 1495105. https://doi.org/10.3389/fpsyg.2025.1495105

Wenzel, T. J. (2007). Collaborative and project-based learning in analytical chemistry. In P. A. Mabrouk (Ed.), *Active learning: Models from the analytical sciences* (ACS Symposium Series, Vol. 970). American Chemical Society. https://doi.org/10.1021/bk-2007-0970.ch005

Yang, H., Mouza, C., & Pan, Y.-C. (2018). Examining pre-service teacher knowledge trajectories of computational thinking through a redesigned educational technology course. In J. Kay & R. Luckin (Eds.), *Rethinking learning in the digital age: Making the learning sciences count, 13th International Conference of the Learning Sciences (ICLS) 2018*. International Society of the Learning Sciences. https://doi.org/10.22318/cscl2018.368

Yazici, H. J. (2020). Project-based learning for teaching business analytics in the undergraduate curriculum. *Decision Sciences Journal of Innovative Education*, *18*(4), 589–611. https://doi.org/10.1111/dsji.12219

Yunus, M., Setyosari, P., Utaya, S., & Kuswandi, D. (2021). The influence of online project collaborative learning and achievement motivation on problem-solving ability. *European Journal of Educational Research*, *10*(2), 813–823. https://eric.ed.gov/?id=EJ1294317

Yusro, A. C., Setyosari, P., Degeng, I. N. S., & Degeng, M. D. K. (2025). Assessing pre-service teachers' analytical thinking in science fundamentals through a Moodle-based online test. *Journal of Educational Technology and Learning Creativity*, *3*(2), 544–553. https://doi.org/10.37251/jetlc.v3i2.2541

Zhang, Y., Zhou, Y., & Qin, K. (2018). Micro-project based curriculum design and teaching practice for modern engineering education in China. In *2018 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE)*. IEEE.

Zohar, A., & Dori, Y. J. (2003). Higher order thinking skills and low-achieving students: Are they mutually exclusive? *The Journal of the Learning Sciences*, *12*(2), 145–181. https://doi.org/10.1207/S15327809JLS1202_1