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The Relationship Of Reflective Thinking Skills And Critical Thinking Skills In Science Problem Solving

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Abstract

To become a competent science teacher, pre-service teachers need to possess well-developed reflective thinking and critical thinking skills, as both play a crucial role in scientific problem-solving processes. Although the theoretical link between reflective thinking and critical thinking is widely acknowledged, empirical validation remains essential to better understand their relationship in educational settings. This study aims to investigate the correlation between reflective thinking skills and critical thinking skills in the context of science problem-solving. A correlational quantitative research design was employed, involving 48 fourth-semester pre-service elementary school teachers enrolled in a science education course at Universitas Muhammadiyah Prof. Dr. Hamka. Participants were selected using a simple random sampling technique. Data were analyzed using Spearman's rank correlation to examine the strength of the relationship between variables and simple linear regression to predict the linear relationship. The results revealed a significant and strong correlation between reflective thinking and critical thinking skills, with a correlation coefficient of 0.779 ($p < 0.001$). Furthermore, a linear relationship was found, as indicated by the regression equation $Y = 82.485 + 1.144X$. These findings emphasize the importance of fostering reflective thinking as a foundational aspect for the development of critical thinking skills in pre-service science teachers.

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INTRODUCTION

Entering the 21st century learning era, learners are required to have high-level thinking skills that support their ability to face the complexities of modern life. One of the essential skills in this context is problem-solving skills, which not only rely on conceptual knowledge, but also on various thinking processes such as critical, creative, analytical, and reflective thinking skills (Kurt, 2018;

Pretorius et al., 2017). In this framework, critical thinking and reflective thinking are two very important skills to be developed through formal education, especially in science learning.

Critical thinking has been recognized as a core academic skill because of its significant role in helping learners understand, analyze, and evaluate information logically and objectively. This skill is very important in responding to the challenges of the 21st century that demand evidence-based problem solving, responsible decision making, and effective communication skills (Moeti et al., 2016; Vieira & Tenreiro-Vieira, 2016). Students who have critical thinking skills tend to be more effective in formulating and solving scientific problems (Saputra et al., 2019; Wahidin & Romli, 2020). Therefore, higher education institutions, especially teacher training institutions, have an important responsibility in fostering critical thinking skills in their curriculum (Bezanilla et al., 2019).

Bibliometric analysis by (Arifin, 2025) revealed that the integration of critical thinking in science education has increased significantly in the last decade, with approaches such as inquiry-based learning showing effectiveness in developing these skills. In addition, (García-carmona, 2025) emphasized the importance of critical thinking in science education as a key to forming citizens who are able to think scientifically and make informed decisions based on evidence.

In the context of science education, critical thinking has two main roles. First, as a means to develop students' scientific responsibility in understanding and applying the principles of science and technology ethically (Yacoubian, 2015). Second, as a basis for strengthening science process skills, including the ability to formulate scientific questions, build data-based arguments, discuss ideas, and evaluate and conclude scientific information rationally (Osborne, 2014; Pedrosa-de-Jesus et al., 2014; Demir, 2015b; Franco et al., 2018; Bedford, 2010)).

Meanwhile, reflective thinking refers to an individual's ability to consciously reflect on learning experiences, assess thinking strategies, and develop a deeper understanding of the cognitive processes they go through. In the constructivist paradigm, reflective thinking allows students to take control of their learning, set personal goals, and identify and address knowledge gaps (Gurol, 2011; Kazu & Demiralp, 2012; Sezer, 2010). This ability includes metacognitive dimensions such as recursive thinking, corrective thinking, and awareness of personal assumptions and perspectives (Kosslyn, 2005). Thus, reflective thinking not only supports conceptual understanding but also strengthens the formation of sustainable scientific problem-solving strategies. Several previous studies have explored the application of various approaches to improve reflective thinking skills in the context of science learning. For example, through the application of problem-based and experimental learning models (Deniř-Çeliker & Dere, 2022), integration of smartboard technology (Bayar & Kurt, 2021), collaborative problem-solving models (Sinensis et al., 2020), and STEM-based approaches such as the integration of the Toulmin Argumentation Model (Gulen & Yaman, 2019) and the cognitive apprenticeship model (Ellianawati et al., 2017). Several survey studies have also been conducted to evaluate the level of reflective thinking of prospective science teachers (Demir, 2015; Hindrasti, 2020), as well as the factors that influence it (Akerson et al., 2018; Can, 2015).

Reflective thinking is a cognitive process that allows individuals to analyze their learning experiences in depth, evaluate understanding, and plan more effective learning strategies. In the context of science education, this skill helps students identify knowledge gaps and develop better solutions to problems faced. A systematic review by Titus (2024) examined 19 intervention studies

related to reflective thinking in schools and found that implementing learning strategies that encourage reflection can improve students' academic performance. Another study by Ulia et al. (2024) highlighted the relationship between complex problem solving and reflective abstraction, suggesting that prior knowledge gained through deep reflection contributes significantly to the effectiveness of complex problem solving.

Reflective thinking and critical thinking are interrelated and mutually reinforcing in the context of science problem solving. Reflective thinking allows individuals to evaluate their own thinking processes, while critical thinking allows them to objectively evaluate external information. A study by Titus (2024) suggests that improving reflective thinking skills can contribute to the development of critical thinking skills. Similarly, a study by Ulia et al. (2024) highlights that reflective abstraction supports complex problem solving, which requires the application of critical thinking to evaluate and select the most effective solution.

Although various studies have examined reflective and critical thinking skills separately, there is still a gap in research that explicitly explores the relationship between the two skills and their contribution to problem-solving abilities in the context of science education, especially among prospective science teachers in Indonesia. This study aims to fill the gap by empirically examining the relationship between reflective thinking skills and critical thinking skills, as well as the contribution of both to science problem-solving abilities. The findings of this study are expected to provide strategic implications in the development of teacher education curriculum based on strengthening higher-order thinking skills.

METHODS

1. Study Design

This study uses a quantitative approach with a correlational survey research design, which aims to determine the relationship between two variables, namely reflective thinking skills and critical thinking skills. Correlational survey research aims to identify the strength and direction of the relationship between two or more variables without manipulating the variables (Creswell & Creswell, 2018).

In the context of education, correlational survey design is very effective for evaluating students' cognitive skills in real-time based on their perceptions and performance (Fraenkel et al., 2019). This study focuses on an empirical understanding of how much reflective thinking skills contribute to critical thinking skills in the context of solving science problems. This design is relevant for use in the field of science education because it provides an objective picture of the relationship between high-level thinking variables in a particular population.

2. Participants

The population in this study were 4th semester students of the Elementary School Teacher Education study program at Universitas Muhammadiyah Prof. Dr. Hamka who took the Science Education course in the odd semester of the 2023/2024 academic year. The simple random sampling technique was used to ensure equal opportunities for each member of the population to be sampled (Noor & Tajik, 2022). The sample consisted of 48 students, consisting of 28 females (60%) and 20 males (40%). The selection of Elementary School Teacher Education students as research

subjects was based on the assumption that critical and reflective thinking skills are needed by prospective teachers in designing problem-solving-based science learning.

3. Measurement

Reflective thinking skills were measured using the Reflective Thinking Questionnaire (RTQ) developed by Kember et al. (2000). This instrument is divided into four main dimensions: Habitual Action (4 items), Understanding (4 items), Reflection (4 items) and Critical Reflection (4 items). The RTQ instrument has been validated in various higher education contexts and has been proven reliable for measuring students' reflective tendencies in learning contexts (Sabekti et al., 2020).

Critical thinking skills were measured using the Critical Thinking Questionnaire (CThQ) developed by Kobylarek et al. (2022). This instrument is structured based on the cognitive domain of Bloom's taxonomy, including: Remembering (3 items), Understanding (4 items), Applying (4 items), Analyzing (4 items), Evaluating (4 items) and Creating (6 items). Kobylarek et al. stated that this instrument has high reliability and is suitable for use in the context of cross-disciplinary higher education, including science education.

The instrument was developed with a 5-point Likert scale, and all data will be checked for validity and reliability before further analysis.

4. Data Analysis

To achieve the main objective of this study, the data obtained will be analyzed in two stages: First, descriptive analysis is used to describe the distribution of reflective thinking skills and critical thinking skills scores of students. The results are presented in the form of frequency distribution tables and percentages. Second, inferential analysis is used to draw conclusions about the population based on sample data, consisting of the Pearson correlation test and the simple linear regression test. The Pearson correlation test is used to measure the strength and direction of the linear relationship between reflective thinking skills and critical thinking skills. While the simple linear regression test was used to predict the value of the critical thinking skills variable based on the value of the reflective thinking skills variable. All analyses were carried out using SPSS software version 25.0 with a significance level of $\alpha = 0.05$.

RESULT AND DISCUSSION

1. Descriptive statistics

Descriptive statistics serve to summarize and present the fundamental characteristics of a dataset, typically using measures such as the mean and standard deviation, thereby enabling researchers to convey a large amount of information in a concise and interpretable form (Mishra et al., 2019). The results of descriptive statistical tests on the variables reflective thinking skills and critical thinking skills measured in this research are displayed in figures 1 and 2.

Based on Figure 1, it can be seen that the level of critical thinking skills most students master is at the understanding stage. This means that in solving problems students are able to give meaning to various types of information, understand texts from various fields, can form different opinions and compare them with each other. they answered each question with a paraphrase derived from their understanding. They think more than just statements, but they can also pay attention to the context of the problem presented

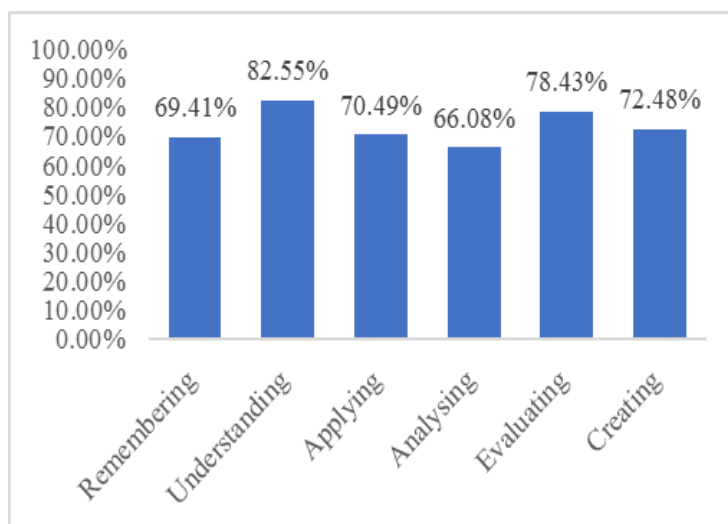


Fig 1. Critical Thinking Skill

Based on Figure 2, it can be seen that the level of reflective thinking skills most students master is at the understanding stage. This means that in solving problems, students utilize the knowledge that students have, without trying to assess that knowledge, so that the problem solving process remains within the meaning scheme and perspective that previously existed in the student.

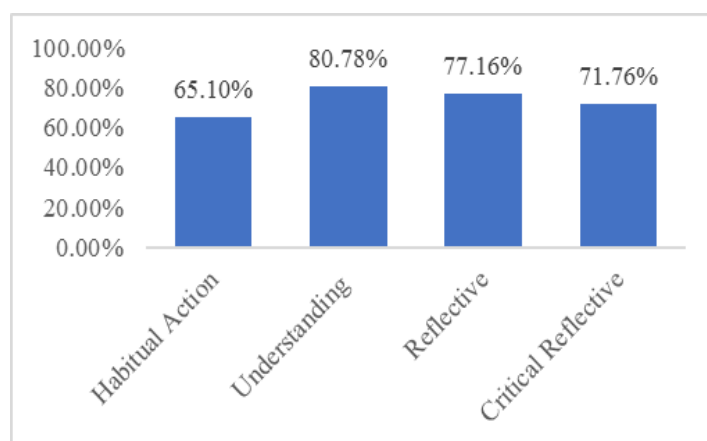


Fig 2. Reflective Thinking Skill

Descriptive results show that most students are at the "understanding" level in both critical and reflective thinking skills. This shows that the majority of students have been able to understand and internalize information, but have not fully reached the analysis and evaluation stage which is part of a higher cognitive level in Bloom's taxonomy (Anderson & Krathwohl, 2001). Achievements at this level of understanding are important, but do not yet reflect the higher-order thinking skills that characterize 21st-century professional teachers.

2. Normality test

The Normality Test is a test carried out with the aim of assessing the distribution of data in a group of data or variables, whether the data distribution is normally distributed or not. The

Normality Test is useful for determining whether data that has been collected is normally distributed or taken from a normal population.

Table 1. Normality Test Results

	Shapiro-Wilk		
	Statistic	df	Sig.
Reflective Thinking	.943	48	.021
Critical Thinking	.952	48	.047

Based on the results of the normality test (shapiro-Wilk), a sig value was obtained. Reflective thinking is $0.021 < 0.05$ and the value is sig. Critical thinking Skills is $0.047 < 0.05$, which means that the two data obtained are not normally distributed. Because the results of the normality test were not met, Pearson correlation could not be used. In such cases, using Spearman's rho is a valid and recommended alternative (Field, 2013).

3. Spearman's Rho Correlation Test

Spearman's rho correlation is a statistical method used to test allegations about the existence of a relationship between variables if the data is on an ordinal scale (rank) or ratio/interval scale but does not meet the assumption of normality. In this test, the correlation value is not calculated based on the actual value of the data, but rather through the ranking that has been given to the data. This correlation coefficient is used to measure the degree of close relationship between one variable and another variable, where observations of each variable are based on giving a certain ranking in accordance with the observations and their partners.

Table 2. Correlation Test Results

	Reflective Thinking	Critical Thinking
Correlation Coefficient		0.779
Sig. (2-tailed)		0.000
N		48

Based on the table, the sig.(2-tailed) value is $0.000 < 0.05$, it can be concluded that there is a significant relationship between reflective thinking skills and critical thinking skills. The correlation coefficient value of 0.779 indicates a very strong and significant relationship between reflective thinking skills and critical thinking. This confirms previous findings that reflective thinking skills play an important role in building and developing critical thinking skills (Eğmir & Ocak, 2020b; Ghanizadeh, 2017).

4. Linearity Test

The linearity test is intended to determine whether there is a linear relationship between the dependent variable and each independent variable to be tested. Linearity test is a requirement for linear regression testing, if a model does not meet the linearity requirements then the linear regression model cannot be used.

Table 3. Linearity Test Results

		Mean Square	F	Sig.
Between Groups	(Combined)	427.123	8.301	.000
	Linearity	4936.277	95.939	.000
	Deviation from Linearity	176.615	3.433	.002
Within Groups		51.452		
Total		478.575		

The results of the linearity test show that the relationship between the two variables is significantly linear (sig. <0.05). This means that every increase in reflective thinking skills will consistently be followed by an increase in critical thinking. This linear relationship model is in line with the theoretical framework of Dewey (1933) and is confirmed by the results of a recent study by (Can, 2015) which shows a strong linearity between reflective activities and the development of students' analytical and evaluative aspects.

5. Simple Linear Regression Test

Simple linear regression analysis is a regression method that can be used as a statistical inference tool to determine the influence of an independent variable on a dependent variable. The linear regression test has several objectives, namely: (1) Calculating the average estimated value and value of the dependent variable based on the value of the independent variable, (2) Testing the dependency characteristic hypothesis, and (3) Predicting the average value of the independent variable based on the value of the independent variable is outside the sample range.

Table 4. Simple Linear Regression Test Results

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.719	0.517	0.506	10.021

Based on the table 4, the value of $R^2 = 0.517$ is obtained, which means that student critical thinking skills is influenced by reflective thinking skills by 51.7%. This also means that there are other influences besides reflective thinking skills and at 48.3%.

Table 5. Simple Linear Regression Test Results

Model	Unstandardized Coefficients		Standardized Coefficients	Sig.
	B	Std. Error	Beta	
(Constant)	82.485	9.245		0.000
Critical Thinking	1.144	0.163	0.719	0.000

Based on the table 5, the results of the simple linear regression analysis revealed a statistically significant and positive relationship between reflective thinking skills (independent variable) and critical thinking skills (dependent variable). As presented in Table 5, the unstandardized regression coefficient (B) for reflective thinking was 1.144 ($p < .001$), indicating that for every one-unit increase in reflective thinking skills, the critical thinking score increases by approximately 1.144

units. This finding suggests that reflective thinking serves as a meaningful predictor of students' critical thinking abilities.

Furthermore, the regression model includes a constant (intercept) of 82.485, which represents the estimated value of critical thinking when reflective thinking is at zero. Although such a condition is unlikely in practical terms, the intercept remains important in determining the overall regression equation. The standardized beta coefficient was 0.719, signifying a strong effect size and confirming the substantial contribution of reflective thinking to variations in critical thinking among preservice elementary science teachers.

Accordingly, the regression equation derived from the analysis is as follows $Y = 82.485 + 1.144X$ where Y represents the predicted score of critical thinking and X represents the score of reflective thinking. This linear model demonstrates that reflective thinking significantly explains the variance in students' critical thinking skills. These results corroborate previous findings that emphasize the foundational role of reflective thinking in the development of higher-order thinking skills, including critical thinking (Ghanizadeh, 2017; Leung & Kember, 2010). The strength and direction of the relationship also align with theoretical perspectives that view critical thinking as a higher-level extension of reflective processes (Kember et al., 2000; Phan, 2011).

The purpose of this study was to determine the relationship between reflective thinking skills and critical thinking skills of prospective teachers. Based on the results of the correlation analysis, it can be seen that there is a very strong relationship between critical thinking and reflective thinking. Given that theoretically there are several similarities in these two forms of thinking skills, the strong relationship in the findings of this correlation analysis supports and strengthens the theory. The results of this correlation analysis support the results of studies that link critical thinking skills with reflective thinking (Eğmir & Ocak, 2020a; Ghanizadeh, 2017; Gogus et al., 2020)

This finding is consistent with various previous studies that state that reflective thinking is the foundation for the development of critical thinking skills thinking (Eğmir & Ocak, 2020; Ghanizadeh, 2017; Aryani et al., 2017)). Reflective thinking skills encourage individuals to review their experiences and knowledge, which are the basis for forming logical arguments and in-depth analysis. Junsay (2016) showed that teachers with high reflective thinking skills tend to have better critical thinking skills. In fact, some researchers consider critical thinking as an advanced phase of reflective thinking researchers (Kember et al., 2000; Leung & Kember, 2010; Phan, 2011). Empirical research has emphasized the importance of the reflective thinking training phase and critical thinking skills in the teaching and learning process researchers (Ghanizadeh, 2017; Kember et al., 2000; Leung & Kember, 2010; Phan, 2011). Therefore, studying students' critical and reflective thinking skills is important (Demir, 2015; Gogus et al., 2020).

The many variables that influence critical thinking and reflective thinking and these variables are not known for certain make it difficult for students to acquire these skills skills (Manalo et al., 2013). Therefore, this study is important to investigate the subdimensions and variables that influence, as well as the relationship between critical thinking and reflective thinking. In future research, critical thinking and examining other variables that influence reflective thinking can enrich the research series and contribute to a better understanding of both ways of thinking.

As a practical implication, lecturers or managers of teacher education programs need to integrate reflective activities in each course, so that students not only develop conceptual understanding, but also metacognitive skills that are essential in the professional decision-making

process. This study makes an important contribution to the development of teacher education curricula, especially in designing learning approaches that can foster high-level thinking skills. The results of the study indicate that strengthening reflective thinking skills will have a significant impact on improving students' critical thinking skills. Therefore, the main implication of this finding is the need for a more explicit and systematic learning approach in developing reflective skills in higher education environments.

However, this study has several limitations. First, the relatively limited number of samples (48 students) and only coming from one educational institution can limit the generalizability of the findings. Second, the measurement of reflective and critical thinking skills in this study used self-report and cognitive test-based instruments, which may not fully describe students' actual abilities in real contexts. Third, this study is correlational, so it cannot fully explain the causal relationship between the two variables.

Therefore, further studies are recommended to involve more institutions and use longitudinal or experimental designs to test the effects of reflection-based learning interventions on the development of critical thinking in more depth. In addition, it is also important to explore the effects of other variables such as emotional intelligence, learning styles, and academic environmental factors on reflective and critical thinking skills.

CONCLUSIONS

Based on the results of the analysis and discussion, it can be concluded that there is a significant relationship between reflective thinking skills and critical thinking skills with a correlation value of 0.779 (very strong). Apart from that, there is also a linear relationship between creative thinking skills and communication skills, so that students' critical thinking skills scores can be predicted using reflective thinking scores using the equation $Y = 82.485 + 1.144X$

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CONFLICTS OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest related to the research, authorship, and publication of this article. If in the future such a thing is found, full responsibility for it lies with the author.

AUTHOR CONTRIBUTIONS

Diki Rukmana conducted the research, performed the data analysis, and drafted the manuscript as the lead author. Mr. Andi Suhandi and Mr. Achmad Samsudin served as academic supervisors who provided guidance, critical evaluation, and direction throughout the development of this scholarly article. All authors have read and approved the final version of the manuscript.

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