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The Relationship Between Science Process Skills and Critical Thinking of Grade IV Students in East Ungaran District

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Abstract

Science process skills (SPS) and critical thinking are essential competencies in elementary science education; however, multi-school evidence concerning their relationship among fourth-grade students remains limited. This study examined the relationship between SPS and critical thinking among fourth-grade students attending public elementary schools in East Ungaran, Indonesia. A quantitative correlational design was employed, involving 105 students selected through cluster sampling from four schools. Data were collected from May to June 2025. SPS was assessed using six process indicators, whereas critical thinking was measured using five categories adapted from Ennis's framework. Instrument trials involving 22 fifth-grade students yielded reliability coefficients of .715 for SPS and .794 for critical thinking. Data were analyzed using SPSS 26 through normality, homogeneity, linearity, and Pearson product–moment correlation tests. The data satisfied the reported assumptions, including normality (p = .065) and linearity (deviation from linearity, p = .125). The results revealed a positive, statistically significant relationship between SPS and critical thinking (r = .601, p < .001, N = 105), representing approximately 36.1% shared variance. Thus, stronger science process skills were associated with higher critical-thinking performance. This study contributes multi-school correlational evidence concerning the relationship between these competencies and supports elementary science instruction that explicitly integrates observation, interpretation, prediction, questioning, communication, and evidence-based reasoning.

Keywords: Correlational Study; Critical Thinking; Elementary Science Education; Fourth-Grade Students; Science Process Skills

INTRODUCTION

Science learning in elementary school needs to build knowledge as well as scientific working methods that are in accordance with the stage of student development. Science process skills provide space for students to observe, classify, interpret, predict, ask questions, and communicate results through active learning activities (Angelia et al., 2022). Critical thinking complements the scientific process because students need to assess information, formulate reasons, draw conclusions, and determine logical responses to learning problems (Daga et al., 2022). The conceptual relationship between the scientific process and reasoning is seen when students use evidence before accepting or rejecting a conclusion (Pradana et al., 2020).

Strengthening both competencies requires a learning experience that does not stop at memorizing concepts. Analysis of primary school textbooks shows that the emergence of the skill aspect of the science process has not always been balanced, especially when the material emphasizes more observation than the more complex scientific process (Darmayanti et al., 2021). Project-based assessments connected to real experiences provide space for scientific attitudes and science process skills to develop through tasks that demand data collection and processing (Parmiti et al., 2021). High-level questions also encourage elementary school students to explain reasons and assess answers more deeply (Achmad & Utami, 2023). The combination of scientific activities and the demands of reasoning is the basis that PPP is worthy of study along with critical thinking skills.

The preliminary study in grade IV-A SD Negeri Sidomulyo 04 showed that the mastery of indicators was not evenly distributed. The PPP profile reached 77% in observing, 73% in grouping, 64% in interpreting, 67% in predicting, 72% in asking questions, and 75% in communicating. The achievement of critical thinking showed 63% in providing simple explanations, 58% in building basic skills, 69% in making inferences, 98% in providing further explanations, and 56% in setting strategies and tactics. The results of the observation also show that student participation is not consistent when learning requires exploration and reasoning. The preliminary picture provides an empirical basis for testing whether the variation in PPP is in line with critical thinking ability over a wider school scope.

Correlation research in grade V students found a significant relationship between science literacy and science process skills (Danianty & Sari, 2022). The development of measuring devices shows that PPP indicators in elementary schools can be poured into instruments that are systematically tested for validity and reliability (Aisah & Agustini, 2024). The critical thinking profile of elementary school students also shows that many students are still in the low to medium category when facing problems that require analysis (Dewi et al., 2023). The Science, Environment, Technology, and Society-based module shows the strengthening of critical thinking skills after learning to connect science with the environment, technology, and society (Yulianti & Herpratiwi, 2024). The project-based learning model provides positive results for science process skills through project activities that require the active involvement of students (Apriansyah et al., 2024). Habituation of science HOTS questions also results in better critical thinking achievements than ordinary learning (Sidiq et al., 2021).

Previous studies have placed PPP and critical thinking more as a result of learning interventions or linking each competency to other variables. Direct correlation evidence between PPP and critical thinking in grade IV students covering multiple schools in a single region is still limited. The novelty of the research lies in testing the relationship between the two competencies through data of 105 students from four public elementary schools with six PPP indicators and five groups of critical thinking indicators. The foundation of analysis places scientific work as a process that requires attention to evidence, while critical thinking works when students assess evidence, make inferences, and formulate reasons. This position makes the relationship between PPP and critical thinking worthy of empirically testing without assuming a cause-and-effect relationship.

The focus of the research is directed at the tendency of the relationship between PPP and critical thinking of grade IV students at SD Negeri Kecamatan Ungaran Timur. The purpose of the study was to determine the direction, strength, and significance of the relationship between the two variables. The research hypothesis states that PPP has a positive and significant relationship with critical thinking skills.

METHODS

The study uses a quantitative approach with a correlational design because the main purpose of the study is to measure the statistical relationship between science process skills and critical thinking without providing experimental treatments. The target population includes grade IV students enrolled in public elementary schools in East Ungaran District, Semarang Regency, Central Java. The cluster sampling technique was chosen because the population is spread across several schools. Four schools were selected as research clusters, namely SD Negeri Gedanganak 02, SD Negeri Kalirejo 01, SD Negeri Kalirejo 02, and SD Negeri Sidomulyo 04. The final analysis involved 105 grade IV students.

The main instrument of science process skills consists of 12 essay questions that include six indicators, namely observing, grouping, interpreting, predicting, asking questions, and communicating. The question material uses the topic of elementary school science about the parts and functions of the plant body and photosynthesis. Critical thinking skills are measured through 10 essay questions developed based on five groups of Ennis indicators, namely providing simple explanations, building basic skills, making inferences, providing further explanations, and setting strategies and tactics. Supporting instruments include questionnaires, observation sheets, interview guidelines, and documentation. The supporting instrument serves to provide contextual information about students' learning conditions and the implementation of science-related activities, rather than replacing the main test scores used in correlation analysis.

The quality of the instrument is checked before the main data collection. The trial involved 22 students in grade V at SD Negeri Sidomulyo 04. The research report states that all the items that are retained meet the validity criteria used. Reliability testing yielded a Cronbach's alpha coefficient of 0.715 for the science process skills instrument and 0.794 for the critical thinking instrument; Both are categorized as having high reliability based on classification in source research. The level of difficulty and distinguishing power of the items are also analyzed at the trial stage so that the final question is considered suitable for use in the main data collection.

Data analysis was carried out using SPSS version 26. The sequence of analysis included a descriptive review of the available supporting data, a Kolmogorov-Smirnov normality test, a Levene homogeneity test, a linearity test, and a Pearson Product Moment correlation. The hypothesis is tested at a significance level of 0.05 and the relationship is declared significant when the probability value is less than 0.05. The proportion of shared variance is calculated through the square of the correlation coefficient multiplied by 100% as a proportional picture of the relationship between the two variables. These values are treated as a descriptive measure and are not used as evidence of cause-and-effect relationships.

Field activities based on research documentation took place during May-June 2025. The ethical approval was issued by the Research Ethics Committee of Ngudi Waluyo University with Number 275/KEP/EC/UNW/2025 dated May 27, 2025. The research was also carried out using school permission and maintaining the identity of students as confidential research information. Interpretation of results is limited to the character of the correlation design and the environment of the participating schools.

RESULTS

The research findings are presented through the quality of the instruments, fulfillment of statistical assumptions, the Pearson Product Moment correlation, and the profile of indicators obtained from the preliminary study. The primary analysis involved 105 fourth-grade students from public elementary schools in East Ungaran District. The presentation in this section is limited to empirical findings, while their theoretical interpretation and comparison with previous studies are discussed separately in the Discussion section.

Table 1. Quality of the Instruments Used in the Primary Research

Variabel	Final Item	Measured indicators	Cronbach's alpha	Interpretasi
Science process skills	12 Essay Questions	6	0,715	Height
Critical thinking	10 essay questions	5 groups	0,794	Height

Table 1 shows the quality of the instruments used to measure science process skills and critical thinking. The science process skills instrument consisted of 12 essay questions covering six indicators: observing, classifying, interpreting, predicting, questioning, and communicating. Its Cronbach's alpha coefficient was 0.715. The critical thinking instrument consisted of 10 essay questions covering five indicator groups: providing simple explanations, building basic skills, making inferences, providing further explanations, and determining strategies and tactics. The Cronbach's alpha coefficient for this instrument was 0.794. Both coefficients were classified as high, indicating adequate consistency of the instruments used in the primary data collection.

Table 2. Pearson Prerequisite and Correlation Test Results

Analysis	Statistics/Coephysions	Value p	Verdict
Normalitas Kolmogorov-Smirnov	D = 0.084	0,065	Normality assumptions are fulfilled
Homogenitas Levene	F = 0,001	0,975	Varians homogen
Deviation from linearity	F = 1,578	0,125	There are no significant deviations in linearity
Korelasi Pearson	r = 0,601	< 0.001	Positive and significant relationships

Table 2 presents the results of the statistical prerequisite tests and Pearson correlation analysis. The Kolmogorov-Smirnov normality test produced a p-value of 0.065, while the Levene homogeneity test produced a p-value of 0.975. The deviation from linearity test yielded a p-value of 0.125. Since all significance values exceeded 0.05, the data met the assumptions of normality, homogeneity, and linearity required for Pearson Product Moment correlation analysis.

The Pearson correlation result reported in Table 2 yielded a coefficient of $r = 0.601$ with $p < 0.001$ for 105 students. The coefficient indicates a positive and statistically significant relationship between science process skills and critical thinking. The coefficient of determination was approximately 36.1%, meaning that 36.1% of the shared variation between the two measured variables was represented by the correlation coefficient. This percentage is interpreted as shared variance and does not establish a cause-and-effect relationship.

Table 3. Profile of Indicators of Preliminary Studies at SD Negeri Sidomulyo 04

Science process skills	Percentage	Critical thinking groups	Percentage
Observing	77%	Provide a simple explanation	63%
Grouping	73%	Build basic skills	58%
Interpret	64%	Making inferences	69%
Predictions	67%	Provide further explanation	98%
Ask a question	72%	Setting strategies and tactics	56%
Communicate	75%	-	-

Table 3 presents the achievement profile of science process skills and critical thinking indicators identified during the preliminary study at SD Negeri Sidomulyo 04. Among the science process skills indicators, observing recorded the highest percentage at 77%, followed by communicating at 75%, classifying at 73%, questioning at 72%, predicting at 67%, and interpreting at 64%. Among the critical thinking indicator groups, providing further explanations reached the highest percentage at 98%, followed by making inferences at 69%, providing simple explanations at 63%, building basic skills at 58%, and determining strategies and tactics at 56%. These percentages show that achievement varied across the indicators measured in the preliminary study.

DISCUSSION

The positive correlation of r = 0.601 indicates that higher science process skills tend to occur alongside higher critical thinking abilities among fourth-grade students. Scientific activities such as observing, interpreting, predicting, questioning, and communicating require students to acquire information, examine evidence, and formulate reasoned conclusions. Critical thinking involves related cognitive processes because students must evaluate information and determine whether a conclusion is logically supported. Differentiated science inquiry has also been reported to develop science process skills and critical thinking simultaneously through structured investigative activities (Ramlawati et al., 2025). HOTS-based science questions similarly encourage elementary school students to provide reasons and evaluate information more deeply (Sidiq et al., 2021). These findings reinforce the conceptual connection between scientific processes and critical reasoning without suggesting that both represent identical constructs.

Evidence from intervention studies provides further context for understanding this relationship. Problem-based learning has been associated with better critical thinking performance among elementary school students than expository learning because students are required to examine problems, identify relevant information, and formulate solutions (Darmawati & Mustadi, 2023). Problem-based learning and inquiry models have also been reported to strengthen critical thinking through problem analysis and active answer-seeking activities (Haryanti et al., 2022). SiSimilar findings have been reported for problem-based learning supported by stop-motion animation (Kaffah et al., 2023). Problem-based learning has also been shown to develop students' abilities to analyze, evaluate, and solve problems (Fathurrohman et al., 2025). Such intervention evidence does not explain the cause of the correlation identified in the present study, but it illustrates that learning environments involving active investigation commonly provide opportunities for critical reasoning.

The relationship identified in the present research can also be considered alongside studies examining science process skills in relation to other learning factors. Learning interest has been positively associated with elementary students' science process skills, suggesting that greater engagement in learning corresponds with the quality of scientific activities performed by students (Amalina & Suryani, 2026). Scientific attitudes also show a positive relationship with science process skills because accuracy and openness toward evidence are relevant to observation and conclusion-making processes (Laily & Suryani, 2026). Curiosity among fourth-grade students has likewise been positively related to science process skills in elementary school settings (Waruwu & Suryani, 2026). The present findings extend this pattern by identifying critical thinking as another competency that varies in the same direction as science process skills.

Learning activities that emphasize problem solving provide another perspective on the relationship between scientific processes and reasoning. Problem solving assisted by the Questions Box Challenge has been reported to improve elementary students' critical thinking in science learning (Maghfiroh & Suryani, 2026). Guided Inquiry-STEAM also provides exploratory learning experiences that combine inquiry processes with higher-order thinking among elementary school students (Suryani et al., 2025). Critical thinking profiles in elementary science further indicate that students require consistent exposure to tasks demanding analysis rather than merely recalling factual information (Kumala et al., 2025). These studies support the relevance of learning activities that connect scientific investigation with reasoning demands, although they cannot be interpreted as direct causal explanations for the correlation obtained in the present research.

The preliminary study presented in Table 3 offers a more detailed picture of differences among individual indicators. Observing reached 77%, whereas interpreting reached 64%, indicating that students performed better in identifying information than in processing its meaning. A wider difference appeared among critical thinking indicators, where providing further explanations reached 98% while determining strategies and tactics reached only 56%. Such variation suggests that descriptive and explanatory abilities did not develop at the same level as skills requiring strategic decision-making. Critical thinking therefore needs to be strengthened through repeated tasks that require students to analyze evidence, compare possible explanations, and determine appropriate decisions. Continuous practice in examining reasons and improving decisions is also emphasized in previous research (Suratmi & Sopandi, 2022).

The shared variance of 36.1% indicates that science process skills and critical thinking have a meaningful degree of statistical association while remaining distinct competencies. A substantial proportion of variation is still related to factors outside the two variables measured in this research. From an instructional perspective, science process activities can be accompanied by explicit reasoning demands. Observation, for example, can be followed by evidence-based questions; classification can require students to justify the criteria used; and prediction can be accompanied by explanations of the reasoning supporting the predicted outcome. Such integration allows students' reasoning processes to become more visible than assessment practices that focus only on whether the final answer is correct.

Several limitations should be considered when interpreting these findings. The correlational and cross-sectional design does not permit causal conclusions between science process skills and critical thinking. The sample was limited to 105 fourth-grade students from four public elementary schools in one district, which restricts the scope of generalization. Essay-based instruments also depend on scoring consistency and students' ability to express their reasoning in written form. Further research may involve broader geographical coverage, longitudinal or intervention designs, and more detailed analysis of individual indicators to clarify how specific dimensions of science process skills relate to particular aspects of critical thinking.

CONCLUSION

Science process skills have a positive and statistically significant relationship with the critical thinking abilities of fourth-grade students in public elementary schools in East Ungaran District, as indicated by $r = 0.601$, $p < 0.001$, and $N = 105$. The shared variance of approximately 36.1% indicates that the two competencies are meaningfully associated, although the correlational design does not support a causal interpretation. Empirical evidence from four public elementary schools contributes to the understanding that science process skills and critical thinking are closely related but remain distinct competencies in elementary science learning. The findings also support the integration of observing, interpreting, predicting, questioning, and communicating activities with evidence-based reasoning in science instruction. Future research should involve broader and more diverse samples, apply longitudinal or intervention designs, and examine relationships at the indicator level to provide a more detailed understanding of the connection between science process skills and critical thinking.

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