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# The Survey on Scientific Reasoning Skill of Pre-Service Elementary Teacher in Indonesia

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**Abstract.** Scientific reasoning skills are a crucial competency to be developed in 21st-century education. This research aims to analyze the profile of pre-service elementary teachers' scientific reasoning skills. This study employs a survey conducted on students in public and private universities in Indonesia. The data collection technique utilizes a three-tier multiple-choice test. The data analysis technique is descriptive. The results of the analysis indicate that the scientific reasoning skills of pre-service elementary teachers are in the low category, with their level of confidence in solving the problems also being low. These findings imply the necessity of developing scientific reasoning skills as an effort to enhance the higher-order thinking skills of pre-service elementary teachers.

**Keywords:** scientific reasoning skill; preservice elementary teacher; confidence levels

## INTRODUCTION

Scientific reasoning skills are a form of higher-order thinking skills and are essential for development in the 21st century (Fatimah et al., 2025; Kambeyo & Scapo, 2018). These skills are crucial and a primary goal in science education. Bruckermann et al. explain that scientific reasoning skills positively influence scientific knowledge and problem-solving (Bruckermann et al., 2023; Malone & Schuchardt, 2023; Thompson et al., 2018). Science learning emphasizes inquiry activities, and scientific reasoning skills are a prerequisite for students to master scientific activities. This indicates that scientific reasoning skills are key to ensuring effective science learning (Bhaw et al., 2023). Low scientific reasoning skills lead to a decrease in the inquiry process experienced by students and hinder the achievement of learning outcomes (Burgess et al., 2017; Edward et al., 2017; Gray et al., 2017; Phillips et al., 2018; Stylinski et al., 2020).

Developing scientific skills is challenging because it involves complex cognitive processes (Rantong & Sarnkong, 2024) and relies on advanced cognitive abilities (Gjoneska, 2021). Students must be able to identify the overall problem, explain the relationship between conclusions and supporting evidence, and evaluate and verify information based on evidence (Bhaw et al., 2023; Bicak et al., 2021). These elements are key in helping students move beyond memorization and equip them with methodical scientific skills and critical thinking about the issues around them (Krell et al., 2020; Luo et al., 2020). Furthermore, scientific reasoning skills help students filter knowledge through inductive and deductive approaches before incorporating it into their cognitive structure. The knowledge learned is then transferred to new situations or hypotheses. This process demonstrates a connection between analytical thinking skills and scientific reasoning skills (Jastrzębski & Chuderski, 2022; Krell et al., 2023). Which ultimately strengthens scientific inquiry (Küçükaydın & Ayaz, 2025).

Scientific reasoning skills are a crucial part of a preservice teacher's professional competence. This highlights the need to equip future educators with the abilities necessary for professional reflection on the learning process (Carlson et al., 2019; Küçükaydın & Ayaz, 2025). Given the importance of scientific reasoning skills for preservice teachers, many researchers have explored this topic. Krell, for instance, conducted a survey study with 438 preservice science teachers and found that science content knowledge is a prerequisite for developing their scientific reasoning skills. This makes it incredibly important for future teachers to cultivate these skills (Krell et al., 2023). Similarly, Kara & Aslan, in their mixed-methods study with 53 preservice science teachers, found that these candidates offered suggestions regarding the contribution of their coursework to the development of scientific reasoning skills (Kara & Aslan, 2024). Lieberei et al. also investigated the need for preservice science teachers to possess scientific reasoning

skills as preparation for their early careers. Their research resulted in recommendations emphasizing the importance of improving scientific reasoning skills for preservice science teachers as part of their professional development (Lieberei et al., 2024).

Previous research has thoroughly explained the importance of scientific reasoning skills for preservice elementary teachers. However, these studies have largely focused on scientific reasoning skills for preservice science teachers, leaving a gap in research concerning preservice elementary teachers. Developing scientific reasoning skills in preservice elementary teachers is crucial because they will be responsible for fostering these very skills in students at the most foundational level. This point is reinforced by research from Koyunlu Ünlü et al. which highlights the significance of developing scientific reasoning for preservice elementary teachers due to their currently low levels of scientific reasoning (Koyunlu Ünlü et al., 2024). The elementary school level is a critical stage where students are in their golden age possessing high levels of creativity. Therefore, it's essential to cultivate specific skills, especially scientific reasoning, from an early age (Kinyota, 2025; Koerber & Osterhaus, 2021; Mambetalina et al., 2023; Rantong & Sarnkong, 2024).

Based on the explanation above, this study aims to analyze the scientific reasoning skills of preserved elementary teachers within their Basic Concepts of Science course. Investigating the scientific reasoning skills of these future educators can provide valuable recommendations for lecturers. It helps them identify specific areas where students' scientific reasoning abilities are lacking. This insight can then guide the design of more effective learning strategies aimed at developing the critical and analytical thinking skills of preservice teachers. Ultimately, this prepares them to teach science to elementary school students using a more in-depth approach.

## METHODS

This is a survey research study. Survey research is a part of the quantitative approach that aims to describe trends, attitudes, or opinions of a population by studying a sample from that population. Researchers can make generalizations or claims about the population based on findings from the sample (Creswell, 2014). Survey research is also conducted to describe individuals, events, or conditions by studying them as they are. Researchers do not manipulate variables but merely describe the sample or variables (Susongko et al., 2024).

### Respondent

The respondents in this study consisted of 198 preservice elementary teachers who had completed the Basic Concepts of Science course. The study was conducted across 5 public and private universities in Central Java, Indonesia.

**Table 1.** Respondent Characteristics

| No | Aspect | N (%) |
|---|---|---|
| 1 | Female | 81.32 |
| 2 | Male | 18.68 |
| 3 | Public | 42.42 |
| 4 | Private | 57.58 |

Table 1 illustrates that the majority of respondents are female, accounting for 81.32%, while males make up 18.68%. In terms of institutions, 42.42% of respondents are from public universities and 57.78% are from private universities.

### Data Collection Method and Instruments

The instrument used in this study was a test sheet. The test was designed in a three-tier multiple-choice format. Three-tier tests offer advantages as diagnostic tools for student misconceptions and overcome the limitations of traditional multiple-choice tests (Arslan et al., 2012; Jusniar et al., 2021; Peşman & Eryılmaz, 2010). This tiered format includes the reasoning behind an answer and the level of confidence in that answer. By using a tiered test, respondents have the opportunity to provide evidence supporting their responses to the given questions. This evidence then serves as a basis to support claims or decision-making. Without further exploration of the answers, the scientific reasoning process involved in problem-solving remains low. Furthermore, it's understood that contextual information within test items can encourage students to be more active in the problem-solving process (OECD, 2006, 2015). Additionally, the inclusion of confidence items has a positive impact on individuals when solving problems. Confident students tend to have a deeper understanding of the material, which increases their accuracy in answering questions (Yang, 2022).

The scientific reasoning skill test uses indicators developed by Lawson (Lawson, 2004) and Jing Han (Han, 2013) comprising 8 aspects:

Control of Variables, Combinatorial reasoning, Proportional & Rations reasoning, Probabilistic reasoning, Correlational reasoning, Deductive Inductive, Causal Reasoning, dan Hypothetical-Deductive Reasoning. Before being administered to respondents, the instrument was validated for content by 7 experts. It also demonstrated good construct validity and was deemed reliable according to Cronbach's Alpha coefficient standards.

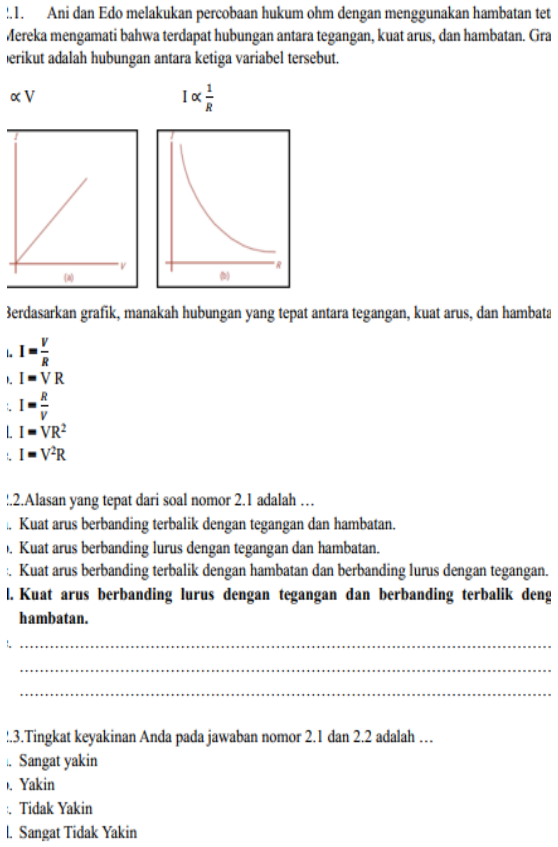


**Figure 1.** Example of Three-Level Scientific

The test was administered in Bahasa Indonesia (the national language) to make it easier for respondents to analyze the questions. Data was collected over a one-month period, from February to March 2025, using Google Forms. The researchers distributed the test link to respondents via social media platforms. Data confidentiality was maintained throughout the research process by assigning ID numbers during data analysis.

### Data Analysis Techniques

Data analysis was performed using quantitative descriptive statistics through percentages (%). The level of scientific reasoning skills was divided into three levels: high, medium, and low. Furthermore, students' confidence levels were categorized into four levels: very confident, confident, unconfident, and very unconfident.

**Table 2.** Levels of scientific reasoning skills

| No | Level | Score Range |
|---|---|---|
| 1 | High | 24-32 |
| 2 | Medium | 12-23 |
| 3 | Low | 0-11 |

Adapted from (Farillon, 2022; Zulkipli, 2020)

**Table 3.** Self-confidence level

| No | Level | Score Range (%) |
|---|---|---|
| 1 | Very high | 76-100 |
| 2 | High | 51-75 |
| 3 | Low | 26-50 |
| 4 | Very low | 0-25 |

Adapted from (Fakhriani et al., 2022)

## RESULTS AND DISCUSSION

This research aims to analyze the profile of scientific reasoning skills among preservice elementary school teachers in universities across Central Java, considering their level of confidence. Confidence levels were categorized into four tiers: very confident, confident, not confident, and very unconfident in their answers to the test questions. The scientific reasoning skill dimension is divided into 8 aspects: Control of Variables, Combinatorial reasoning, Proportional & Rations reasoning, Probabilistic reasoning, Correlational reasoning, Deductive Inductive, Causal Reasoning, dan Hypothetical-Deductive Reasoning. Table 4 presents the profile of preservice elementary school teachers' scientific reasoning skills, broken down by each dimension (ordered from easiest to most difficult).

Table 4 presents the profile of scientific reasoning skills by gender. Based on the measurement results, the Control of Variables dimension was the most mastered by preservice elementary school teachers, while Probabilistic Reasoning was the most challenging dimension. This finding aligns with Lay's research which also indicated that probabilistic thinking is students' lowest reasoning ability (Lay, 2010). Probabilistic reasoning is a crucial skill in various contexts, especially in science (Primi et al., 2017) and correlates with students' attitudes toward science and their self-confidence (Gazzo Castañeda et al.,

**Table 4.** Profile of Preservice Elementary School Teachers' Scientific Reasoning Skills by Dimensions

| Dimensions | Level | N (%) | | Total |
|---|---|---|---|---|
| | | Male (n=37) | Female (n=161) | |
| Control of Variable | High | 21.62 | 7.5 | 14.56 |
| | Medium | 45.95 | 27.3 | 36.62 |
| | Low | 32.43 | 65.2 | 48.82 |
| Combinatorial Reasoning | High | 18.92 | 7.45 | 13.18 |
| | Medium | 43.24 | 28.57 | 35.91 |
| | Low | 37.84 | 63.98 | 50.91 |
| Correlational Reasoning | High | 16.22 | 6.83 | 11.52 |
| | Medium | 40.54 | 29.19 | 34.87 |
| | Low | 43.24 | 63.98 | 53.61 |
| Causal Reasoning | High | 13.51 | 6.21 | 9.86 |
| | Medium | 37.83 | 29.81 | 33.82 |
| | Low | 48.64 | 63.98 | 56.31 |
| Deductive Inductive | High | 10.81 | 5.60 | 8.20 |
| | Medium | 35.14 | 29.81 | 32.48 |
| | Low | 54.05 | 64.59 | 59.32 |
| Hypothetical-Deductive Reasoning | High | 8.11 | 4.35 | 6.23 |
| | Medium | 32.43 | 28.57 | 30.50 |
| | Low | 59.46 | 67.08 | 63.27 |
| Proportional & Ratio Reasoning | High | 5.41 | 3.10 | 4.25 |
| | Medium | 29.73 | 27.33 | 28.53 |
| | Low | 64.86 | 69.57 | 67.22 |
| Probabilistic Reasoning | High | 2.8 | 1.86 | 2.28 |
| | Medium | 27.02 | 21.74 | 24.38 |
| | Low | 70.27 | 76.40 | 73.34 |

2023; Hokor, 2022). Students with low probabilistic reasoning tend to have poor attitudes toward science, which can lead to poor decision-making (Hokor, 2022).

When examining scientific reasoning skills by gender, males demonstrated better performance compared to females. While this study did not use inferential statistics to measure the relationship between scientific reasoning skills and gender, and this is acknowledged as a limitation, it nonetheless revealed that the scientific reasoning skills of males were superior to those of females. This finding is consistent with research conducted by Luo et al., which similarly showed that males significantly outperformed females in scientific reasoning skills (Luo et al., 2021, 2025).

Figure 2 illustrates that, overall, a significant majority of preserved elementary teachers 59.10% of respondents fall into the low category for scientific reasoning skills. The remaining respondents were categorized as medium (32.14%) and high (only 8.76%). These results confirm that the scientific reasoning skills of most preservice

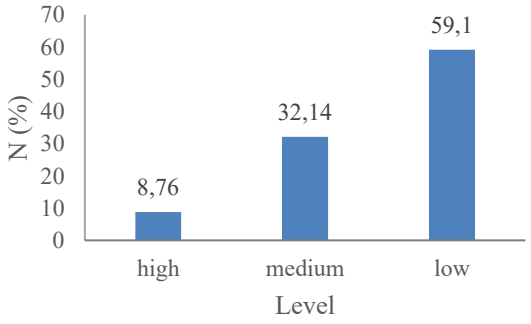


**Figure 2.** Profile of Scientific Reasoning Skills of Preservice Elementary Teachers

elementary teachers are still low, consistent with previous research by Koyunlu Ünlü et al. (Koyunlu Ünlü et al., 2024; Mariana et al., 2018; Pratiwi, 2019; Zulkipli, 2020). This highlights the urgent need for innovative teaching solutions to improve these crucial skills. Designing appropriate and effective learning experiences is a crucial factor in influencing the development of scientific reasoning skills (Abate et al., 2020;

**Table 5.** Respondent Confidence Levels

| No | Levels of scientific reasoning skills | N (%) | | | | Total (%) |
|---|---|---|---|---|---|---|
| | | Very confident | Confident | Unconfident | Very unconfident | |
| 1 | High | 1.01 | 5.73 | 2.02 | 0 | 8.76 |
| 2 | Medium | 2.52 | 6.6 | 12.42 | 10.60 | 32.14 |
| 3 | Low | 5.05 | 7.59 | 30.31 | 16.15 | 59.1 |
| | Total (%) | 8.58 | 19.92 | 44.75 | 26.75 | 100 |

Farillon, 2022; Khoirina et al., 2018; Kocagül & Ünal Çoban, 2022; Utami et al., 2020).

Effective instruction for developing scientific reasoning skills is typically structured and actively engages students in scientific inquiry activities (Bao, 2018).

Beyond gender, the level of confidence in this study was measured to ascertain the respondents' certainty in answering the questions. Table 5 presents the confidence levels of preserved elementary teachers when responding to scientific reasoning skill questions.

Table 5 illustrates the confidence levels of preservice elementary teachers when answering scientific reasoning skill questions, categorized by their skill level. Interestingly, the majority of respondents answered in the unconfident category. However, the results also show that some respondents answered with high confidence, even when their answers were inaccurate. This suggests that these respondents might still harbor misconceptions despite having high self-confidence. This is a crucial point for educators to address, as it highlights the need to strengthen conceptual understanding among preservice elementary teachers. Conversely, preservice elementary teachers who scored in the high category for scientific reasoning skills consistently showed high confidence. This indicates that those with a strong grasp of concepts also tend to have high self-confidence. The findings from this study recommend that strengthening science content knowledge for preservice elementary teachers is key to developing good scientific reasoning skills. Scientific reasoning skills are positively correlated with students' ability to understand science content (Feljone Ragma & Valdez, 2017). Students who can understand science content well are also predicted to possess strong scientific reasoning skills (Bhaw et al., 2023).

## CONCLUSION

The results of the analysis indicate that the scientific reasoning skills of pre-service elementary teachers are in the low category, with their level of confidence in solving the problems also being low. These findings imply the necessity of developing scientific reasoning skills as an effort to enhance the higher-order thinking skills of pre-service elementary teachers. Recommendations for future research include a more in-depth analysis of how to design effective science learning to enhance all aspects of scientific reasoning skills. This study had the limitation of only analyzing the profile of scientific reasoning skills viewed from the self-confidence of preservice elementary school teachers. Future research could also empirically analyze the relationship between self-confidence levels, gender, and scientific reasoning skills. Therefore, further research to measure these aspects can be conducted. Furthermore, it's important for educators to focus on science content-based learning to enhance scientific reasoning skills. This naturally requires innovative science learning designs.

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