
Analysis of Understanding of the Nature of Science (NOS) and Scientific Literacy among Pre-Service Biology Teachers at HKBP Nommensen University Pematangsiantar

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Article Info

Article history:

Received: May 2nd, 2026

Revised: July 4th, 2026

Accepted: July 7th, 2026

Available online: July 31st, 2026

<https://doi.org/10.33541/edumatsains.v11i1.8131>

Abstract

This study aims to examine the understanding of the Nature of Science (NOS) and scientific literacy among pre-service biology teachers at Universitas HKBP Nommensen Pematangsiantar. This study employed a descriptive mixed-method approach, integrating qualitative and quantitative data to provide a comprehensive profile of students' understanding of NOS and scientific literacy. The research employed a descriptive qualitative approach to assess NOS using the VNOS Form B instrument, and a descriptive quantitative approach to evaluate scientific literacy through a 10-item multiple-choice test. The participants consisted of seventh-semester students from the Biology Education Study Program, selected using purposive sampling. NOS data were analyzed interpretively, while scientific literacy data were analyzed using percentage-based achievement. The findings reveal that students' understanding of NOS varies across different aspects. A high proportion of students demonstrated informed views on the tentative nature (88%) and empirical basis (76%) of science; however, 80% still exhibited naïve conceptions in distinguishing scientific theories from scientific laws. The aspects of scientific method, creativity, and subjectivity are classified within the transitional category. Meanwhile, scientific literacy is categorized as high, with an average score of 68.75%, indicating strengths in data interpretation (72%) but weaknesses in designing scientific investigations (54%). These findings emphasize the importance of strengthening inquiry-based learning and enhancing epistemological understanding in teacher education programs, while

providing baseline evidence for improving the integration of NOS and scientific literacy in pre-service biology teacher education.

Keywords: analysis, nature of science, scientific literacy, pre-service biology teachers, Universitas HKBP Nommensen Pematangsiantar.

1. Introduction

Science education in the 21st century requires not only mastery of concepts but also a comprehensive understanding of the Nature of Science (NOS) and the ability to demonstrate scientific literacy (Sirait et al., 2021). These two aspects serve as essential foundations in shaping individuals who are capable of thinking critically, making evidence-based decisions, and understanding the role of science in everyday life (Siahaan et al., 2023). In the context of education, pre-service biology teachers hold a strategic position as key agents in both transferring and constructing scientific understanding among students (Sirait et al., 2023).

The Nature of Science encompasses an understanding of how scientific knowledge is developed, including its tentative and empirical nature, as well as the influence of scientists' creativity and subjectivity (Zhang et al., 2023). Meanwhile, scientific literacy refers to an individual's ability to explain scientific phenomena, evaluate and design investigations, and interpret data and scientific evidence within real-life contexts (Sirait et al., 2025). These two competencies are closely interrelated and serve as important indicators of the quality of science education (Sirait, 2025).

However, various studies indicate that pre-service teachers' understanding of the Nature of Science remains suboptimal (Sirait et al., 2026). Common misconceptions persist, such as the belief that scientific theories can evolve into laws, and the view that the scientific method is rigid and linear (Pardede et al., 2024). In addition, the scientific literacy of pre-service teachers is often limited to content knowledge, while procedural and contextual competencies are not yet fully developed (Silaen et al., 2025). This condition may affect the quality of classroom instruction, as teachers tend to present science as a collection of facts to be memorized rather than as a dynamic process of inquiry (Silaban et al., 2025).

Universitas HKBP Nommensen Pematangsiantar, as one of the teacher education institutions, plays an important role in preparing competent pre-service biology teachers. Therefore, it is essential to examine the extent to which these students understand the Nature of Science and scientific literacy (Silaban et al., 2025). This analysis not only provides an overview of students' competency profiles but also serves as a basis for designing more effective and contextual learning strategies (Alexander, Sirait, et al., 2025).

Based on this background, this study aims to analyze the understanding of the Nature of Science (NOS) and scientific literacy among pre-service biology teachers at Universitas HKBP Nommensen Pematangsiantar. The results of this study are expected to contribute to the development of science education, particularly in improving the quality of pre-service biology teachers who are capable of teaching science in a comprehensive, critical, and relevant manner in response to contemporary demands (Harita et al., 2025).

2. Methods

Study Design

This study employed a descriptive mixed-method design by integrating qualitative and quantitative approaches to provide a comprehensive description of pre-service biology teachers' understanding of the Nature of Science (NOS) and scientific literacy. The qualitative approach was used to explore participants' understanding of NOS, while the quantitative approach was used to describe their scientific literacy achievement. Lederman has developed an instrument that can be used to determine the level of understanding of the Nature of Science (NOS) (Alexander et al., 2025). The instrument used in this study was the VNOS Form B, which has been translated to identify NOS concepts and characteristics (D. L. Pardede et al., 2025).

Procedure

Each question in the instrument is associated with one aspect; however, some questions may cover up to three aspects simultaneously (L. Pardede et al., 2026). For example, question number 1 encompasses three aspects, namely empirical NOS, the scientific method, and tentative NOS. The study was conducted in two sequential stages. First, participants completed the VNOS Form B questionnaire to explore their understanding of NOS. Second, the same participants completed a scientific literacy test to measure their literacy achievement across the assessed dimensions. The instrument was then administered to seventh-semester pre-service biology teachers from the Biology Education Study Program at Universitas HKBP Nommensen Pematangsiantar (Pasaribu et al, 2024).

Data Collection

The participants consisted of seventh-semester pre-service biology teachers from the Biology Education Study Program at Universitas HKBP Nommensen Pematangsiantar. The VNOS Form B was used to collect qualitative data regarding participants' understanding of NOS. The responses obtained from this instrument were interpreted to determine participants' understanding of the Nature of Science among pre-service biology teachers (Siahaan et al., 2026).

Meanwhile, scientific literacy was examined using a quantitative descriptive method through a scientific literacy test consisting of 10 multiple-choice questions (Susanti et al., 2025). These questions represent components of scientific literacy, namely the aspects of science context, science competencies, and science knowledge within the scope of biology (Nopriadi et al., 2022). The test was administered to seventh-semester pre-service biology teachers from the Biology Education Study Program at Universitas HKBP Nommensen Pematangsiantar.

Data Analysis

Qualitative data obtained from the VNOS Form B were analyzed interpretively by categorizing participants' responses according to the NOS aspects assessed. Quantitative data from the scientific literacy test were analyzed descriptively by calculating the percentage of students' achievement using Microsoft Office Excel. The percentage of scientific literacy achievement was then interpreted descriptively based on the following learning outcome criteria:

Table 1. Criteria for Student Learning Outcomes

Score	Criteria
80–100	Very Good
66–79	Good
56–65	Fair
40–55	Poor
30–39	Very Poor

3. Result and Discussion

Results

The results of this study are presented in the following tables:

Table 2. Percentage of Understanding of Nature of Science (NOS)

Aspect of Nature of Science (NOS)	Informed (%)	Transitional (%)	Naive (%)
Tentative Nature	88%	12%	0%
Scientific Law vs Theory	4%	16%	80%
Scientific Method	24%	56%	20%
Creativity in Science	32%	60%	8%
Subjectivity in Science	40%	48%	12%
Empirical Basis	76%	20%	4%

Table 3. Mean Scores of Students' Scientific Literacy

No	Scientific Literacy Aspect	Mean Score (%)	Category
1	Explaining Scientific Phenomena (Content)	68%	High
2	Evaluating & Designing Investigations (Process)	54%	Moderate

3	Interpretation of Data & Scientific Evidence	72%	High
4	Attitudes & Awareness toward Science Issues	81%	Very High
	Overall Average	68.75%	High

Table 4. Distribution of Scientific Literacy Levels (BSCS Framework)

Scientific Literacy Level	Percentage (%)	Brief Description
Multidimensional	18%	Able to relate science to social, ethical, and environmental issues
Conceptual	64%	Understands concepts and relationships among biological concepts
Functional	18%	Understands terms but still relies on memorization

The results indicate that the understanding of the Nature of Science (NOS) and scientific literacy among pre-service biology teachers varies across aspects.

In terms of NOS, respondents demonstrated high understanding in the tentative nature (88%) and empirical basis (76%). However, the main weakness lies in distinguishing between scientific theories and laws, where 80% of respondents are still in the naive category. Meanwhile, the aspects of scientific method (56%), creativity (60%), and subjectivity (48%) are dominated by the transitional category.

Regarding scientific literacy, the highest achievement is found in attitudes toward science (81%) and data interpretation (72%), while the ability to design scientific investigations is the lowest (54%). Overall, the majority of respondents fall within the conceptual literacy level ($\pm 64\%$), with a smaller proportion reaching the multidimensional literacy level ($\pm 18\%$).

Discussion

The findings indicate that pre-service biology teachers have developed a strong foundation in the empirical aspect and awareness that science is dynamic, which are essential for inquiry-based learning (Pardede et al., 2024). The findings demonstrate that pre-service biology teachers exhibit varying levels of understanding across the different aspects of the Nature of Science (NOS), indicating that their epistemological understanding is not yet fully developed. The high percentage of informed views on the tentative nature (88%) suggests that most participants understand scientific knowledge as dynamic and subject to revision when supported by new empirical evidence. This finding is consistent with previous studies emphasizing that recognizing the tentative nature of science is a fundamental component of scientific literacy and inquiry-based science education. However, fundamental misconceptions persist, particularly the

belief that scientific theories can evolve into laws (Sinurat et al., 2026). This reflects a limited epistemological understanding of the structure of scientific knowledge (Sinaga et al., 2024).

In contrast, the Scientific Law versus Theory aspect remains the weakest indicator, with 80% of participants categorized as having naïve conceptions. Many respondents still believed that scientific theories eventually become laws, a misconception that has been widely reported in science education research and reflects an incomplete understanding of the epistemological status of scientific knowledge (Sinaga et al., 2026). The dominance of the transitional category in the scientific method (56%), creativity (60%), and subjectivity (48%) aspects indicates that participants still tend to perceive science as a rigid and procedural activity. Although they recognize the importance of experimentation, many have not yet fully understood that scientific investigations may follow multiple pathways and are influenced by creativity, prior knowledge, and scientists' perspectives (Simatupang et al., 2025). These findings support previous studies arguing that NOS instruction should explicitly address the creative and subjective dimensions of scientific inquiry rather than focusing solely on procedural laboratory activities.

Regarding scientific literacy, participants demonstrated relatively high achievement in interpreting scientific data (72%) and scientific attitudes (81%). These results indicate that respondents are able to analyze scientific evidence and appreciate the importance of science in everyday contexts, which are essential competencies for future science teachers (Silaban et al., 2021). However, the relatively low score in evaluating and designing scientific investigations (54%) reveals that participants still experience difficulties in applying scientific reasoning to plan investigations and solve authentic scientific problems (Saragih et al., 2025). This discrepancy suggests that conceptual understanding has not yet been fully translated into inquiry and problem-solving skills.

Overall, these findings suggest that while pre-service teachers already understand “what science is,” they still need to strengthen their understanding of “how science works.” (Samosir et al., 2026). Therefore, more explicit, reflective, and inquiry-based NOS instruction is needed in teacher education programs (Pane et al., 2025). Overall, the findings indicate that pre-service biology teachers possess an adequate understanding of fundamental scientific concepts but still require stronger epistemological understanding of how scientific knowledge is generated, justified, and revised. These results also provide empirical evidence that integrating explicit NOS instruction with inquiry-based learning may help bridge the gap between conceptual knowledge and scientific inquiry skills. Therefore, teacher education programs should incorporate more explicit, reflective, and inquiry-oriented learning experiences to improve both NOS understanding and scientific literacy.

4. Conclusion

Based on the results of the study, it can be concluded that the understanding of the Nature of Science (NOS) and scientific literacy among pre-service biology teachers at Universitas HKBP Nommensen Pematangsiantar demonstrates a varied profile. Students show strengths in the aspects of the tentative nature and empirical basis of science, indicating that they understand

science as dynamic and evidence-based. However, a fundamental weakness was identified in the distinction between scientific theories and laws, where most respondents still hold the misconception that theories can develop into laws. In addition, in the aspects of scientific method, creativity, and subjectivity, students tend to fall within the transitional category, suggesting that their understanding remains procedural and does not yet fully reflect the flexible and constructive nature of science. In terms of scientific literacy, respondents demonstrate strong abilities in data interpretation and attitudes toward science, but still show limitations in designing and evaluating scientific investigations, highlighting a gap between conceptual understanding and inquiry skills. These findings provide an empirical profile of pre-service biology teachers' NOS understanding and scientific literacy, offering baseline evidence to support the design of more effective inquiry-based and reflective teacher education programs. Therefore, more explicit, reflective, and inquiry-based learning approaches are needed in teacher education to enhance scientific literacy and strengthen epistemological understanding in a comprehensive and sustainable manner.

5. Acknowledgments

The research team would like to express their sincere gratitude to the HKBP Nommensen University Foundation and the Institute for Research and Community Service of Universitas HKBP Nommensen Pematangsiantar for the financial support and prayers provided throughout the course of this study.

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