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NATURE OF SCIENCE PROFILE OF PROSPECTIVE BIOLOGY TEACHER

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Abstract: A strong understanding of NOS will support prospective teachers in teaching science more critically and meaningfully to students, as well as prepare them to face scientific challenges in the future. Therefore, this research aims to analyze the understanding of prospective biology teachers regarding the Nature of Science (NOS) as an important foundation in science education. The method used is a quantitative descriptive survey with the Views of Nature of Science (VNOS) Form B questionnaire instrument. VNOS Form B is an instrument used to measure understanding of the nature of science in certain aspects. The data collection methods used were questions and interviews. This research involves 84 first-year students of the biology education program as participants. Data analysis was conducted using descriptive statistics to determine the percentage of their understanding of NOS based on seven indicator aspects, namely the provisional nature, empirical basis, subjectivity, human inference, creativity, socio-cultural context, and the distinction between observation and inference. The results show that the average understanding of NOS among students falls into the good category with an average of 76%. The indicator with the highest percentage is empirical-based with an excellent category, and the lowest is the relationship between theory and scientific law, which falls into the enough category. The implications of this research encompass several important aspects related to learning, curriculum development, and the enhancement of educator competencies.
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Introduction

Education needs to be designed to develop students' potential to achieve the expected qualifications. The Ministry of Education and Culture (2020) states that graduates must master theoretical concepts in their field of knowledge in depth, formulate procedural problem-solving, and make decisions accurately and responsibly. Science, as one of the fields of knowledge, plays a role in realizing students' potential to meet the desired qualifications. Kolb & Kolb (2017) stated that one of the important goals of science education is to guide students in mastering the fundamental concepts or ideas of science and applying them to explain relevant everyday phenomena.The implementation of scientific concepts, principles, and contexts becomes very important so that science contributes to various fields of life (Hardianty, 2015; Astuti, 2019). The usefulness and role of science can be examined starting from understanding the nature of science (NOS), as a foundation for studying science (Aflalo, 2014; Prachagool & Nuangchalerm, 2019).

Understanding the Nature of Science (NOS) is crucial for prospective science teachers so that they are not only able to teach scientific concepts but also explain the dynamics of science as a continuously evolving process. Various studies in the past five years have shown that prospective science teachers often have a limited understanding of NOS. Among other things, they tend to view science as static knowledge, whereas science is dynamic and can change based on new evidence obtained through research (Cullinane & Erduran, 2022). When prospective teachers do not comprehensively understand the Nature of Science (NOS), it can affect the way they teach science in the classroom, risking an inaccurate portrayal of what science is. In fact, studies exploring the integration of NOS into the curriculum suggest that prospective teachers need to be equipped with an explicit and reflective approach to NOS. Science teacher candidates need to master and apply the Nature of Science (NOS) in their teaching so that students understand science not just as a collection of facts, but also as a dynamic process involving scientific methods, hypothesis testing, and

openness to new evidence. This allows students to see that science is tentative and can change (Donohue et al., 2020). The integration of NOS helps students develop critical understanding and a flexible scientific attitude, which is important in facing future scientific challenges (Khishfe, 2017).

Although the concept of the Nature of Science (NOS) is recognized in educational policy, prospective science teachers often do not receive sufficient training to understand and apply it in the classroom. The teacher education curriculum tends to focus on science content without integrating the Nature of Science (NOS) as a main component. As a result, many prospective teachers are less prepared to teach NOS effectively (Donohue et al., 2020; Khishfe, 2017). Kaya et al., (2018) state that a weak understanding of NOS limits the ability of prospective teachers to facilitate students' scientific thinking in a critical and reflective manner. Therefore, research on the profile of science teacher candidates' understanding of the Nature of Science (NOS) is very important to assess their level of understanding and identify aspects that need improvement in the teacher education curriculum. This profile helps ensure that teacher candidates have a strong foundation to effectively teach NOS, considering that many have not yet received adequate NOS education. (Donohue et al., 2020; Kaya et al., 2018). Addressing these weaknesses in the curriculum can improve the quality of science teaching, providing students with a more accurate understanding of the nature of science. (Arslan & Sagir, 2020). Therefore, the research was conducted with the aim of understanding the patterns or profiles of the nature of science and the metacognitive awareness of first-year students. The results of this study can be used as a basis for designing activities that emphasize explicit-reflective NOS teaching. Further research can explore the effectiveness of specific teaching strategies in enhancing pre-service teachers' understanding of NOS.

Method

This type of research is quantitative descriptive. The method used is a survey method with a questionnaire as a tool for collecting data. The questionnaire was the Views of Nature of Science (VNOS) form B, adapted from Lederman, Abd-El-Khalick, Bell, & Schwartz (Sukaesih et al., 2022). The results of the validity test of the questions on the understanding of the nature of science showed that 7 questions were valid, with a validity value of 0.375-0.659. While the reliability of the test instrument for understanding the nature of science was 0.657 (high). The participants in this study are 84 first-year students in the biology education program.Data were analyzed using descriptive statistics to calculate the percentage of NOS understanding based on the indicators present in the instrument, which consists of seven aspects/indicators, namely science is tentative (can change), empirical-based, subjective, a result of inference, imagination and human creativity, socially and culturally embedded, the difference between observation and inference, and the relationship between theory and scientific law. Students' understanding of the nature of science is divided into five categories: excellent, good, enough, less, poor (Widowati et al., 2018). The following categories of nature of science among prospective teacher students:

Table 1. The categories of nature of science

Percentage	Category
81 - 100	Excellent
61 - 80	Good
41 - 60	Enough
21 - 40	Less
0 - 20	Poor

Result

The nature of science refers to the ability to understand that science is more than just a collection of facts, but rather a way of thinking that involves a critical attitude and openness to change. NOS has significant value because it explains how science functions as a dynamic process that evolves through research and evidence. Data on the understanding of NOS among biology education students as prospective teachers are presented in Table 2 below.

Table 2. Results of NOS understanding among prospective teacher students

Indicator	Percentage	Category
Science is tentative (can change)	85	Excellent
Empirical-based	90	Excellent
Subjective	72	Good
Result of inference, imagination and human creativity	78	Good
Socially and culturally embedded	65	Good
the difference between observation and inference	82	Excellent
the relationship between theory and scientific law	60	Enough
Average NOS	**76**	**Good**

Based on the data in Table 2, the average level of NOS understanding among prospective biology teacher students is 76%, which falls into the good category. This means that the students' understanding of NOS is already good. Understanding NOS allows prospective biology teacher students to know the extent to which they have grasped how science involves the scientific method, the importance of testing hypotheses, and the acceptance of results that can change with new evidence. Mastering learning materials, identifying areas that require deeper understanding. This means that with a good understanding of NOS, prospective biology teacher students have been able to comprehend that science is tentative (can change), empirical, subjective, the result of human inference, imagination, and creativity, embedded in socio-cultural contexts, the difference between observation and inference, and the relationship between scientific theory and law.

Discussion

In general, the research results show that the understanding of the Nature of Science (NOS) among students falls into the good category with an average of 76%. This reflects that the majority of students have a sufficient understanding of basic science concepts, such as the empirical nature of science, the importance of observation and evidence, and how science develops through a systematic process. Students' comprehension even qualifies as exceptional in some areas, such as the empirical nature of science. This suggests that the fundamental steps of the scientific method, observation, data gathering, and making conclusions based on evidence are well understood by the pupils. The practical-based learning strategies frequently used in science education, which actively engage students in the process of exploration and scientific inquiry, may contribute to this achievement.

Students' comprehension still qualifies as sufficient, nevertheless, based on some metrics, such as the connection between scientific theory and scientific law. This suggests that students struggle to comprehend the differences between scientific laws, which are often descriptive and unchanging, and scientific ideas, which are dynamic and subject to modification. To be more specific, it is described in each indicator.

Most respondents (85%) demonstrated an understanding that scientific knowledge is tentative and can change with the discovery of new evidence. (Table 2). This understanding aligns with Lederman's view that scientific knowledge is always provisional and evolving (Sukaesih et al., 2022). However, there are still 15% of respondents who consider science to be something absolute, indicating a fairly common misconception among some students. An absolute understanding of science can lead to misconceptions about the flexible nature of scientific knowledge, making it important for teacher education to emphasize the dynamic nature of science as a continuously evolving discipline (Adi & Widodo, 2018).

The understanding that science is based on empirical evidence (the second indicator) received a percentage of 90%, indicating a strong comprehension of the importance of observation and experimentation in building scientific knowledge. Science as a discipline based on empirical evidence is the main foundation of the scientific method (Muslih, 2020). Students who possess this understanding realize that verifiable empirical data is the foundation of every valid scientific conclusion. The high percentage of this understanding indicates that prospective biology teacher students have internalized the importance of empirical evidence in science.

According to the third NOS indicator, 72% of students are aware that subjectivity in science cannot be disregarded, particularly when choosing research topics and interpreting findings, which are frequently impacted by the backgrounds or opinions of scientists (Curtis, 2015). Even while science aims for objectivity, the opinions of individual scientists nevertheless give the process a subjective touch. Nonetheless, 28% of those surveyed say they are still unclear about this subjective element, highlighting the need for additional conversations on how cultural and personal backgrounds affect the scientific method. The next NOS signal is that human inference, creativity, and imagination lead to science. Students are currently enrolled in introductory biology I, which involves applying theories, looking for factual facts in the field, and using their imagination and creativity to investigate biology and its social context. According to Table 2, 78% of respondents are aware that inference, along with imagination and creativity in interpreting evidence and formulating ideas, are essential to the advancement of research (Kind & Osborne, 2017). Scientists can go beyond direct observation and create theories that offer comprehensive explanations of natural occurrences thanks to the contributions of imagination and inference. But according to 22% of respondents, science is limited.

Scientific knowledge can also be influenced by social and cultural contexts, and this understanding is important because it shows that science does not develop in isolation. This is in line with students' responses to the indicator of Science Embedded in Social and Cultural Contexts. Although only 65% of respondents believe that scientific knowledge can be influenced by social and cultural contexts. This understanding is certainly important because it shows that science does not develop in isolation, but is also influenced by the social, cultural, and economic values of society (Muttaqin et al., 2022). Science embedded in the socio-cultural context allows us to understand that certain scientific discoveries often emerge to meet the specific needs of society. However, 35% of respondents who do not yet understand this aspect indicate the need for more study of the history of science and the cultural role in the development of scientific knowledge.

Understanding of NOS regarding the difference between observation and inference is demonstrated by 82% of respondents, who are able to distinguish between raw data (observation) and the conclusions

drawn from that data. (inferensi). This understanding is important in the scientific method, as it teaches students to recognize the boundary between what they see directly and their interpretation of the data. However, 18% still struggle with this concept, which can be interpreted as needing efforts or strategies to strengthen their foundational understanding in the scientific process, either through learning processes or experiments/practicals.

Just 60% of respondents were aware of the distinction and connection between scientific theory and law, according to the final indication. Forty percent of respondents still believe that a hypothesis will become law once it is demonstrated to be correct. However, the functions of scientific laws and theories differ; while laws identify patterns or consistencies in natural occurrences without offering explanations or mechanisms, theories provide thorough explanations. This misunderstanding emphasizes the need for more NOS-related instruction in the domains of theory and law, particularly in dispelling the myth that laws are derived from scientific theories.

Conclusion

Understanding of NOS among prospective biology teachers varies, with the empirically-based aspect showing the highest understanding (very good, 90%) and the aspect of the relationship between theory and law having the lowest understanding (sufficient, 60%). As for the other five indicators, namely tentative scientific knowledge (excellent, 85%), subjectivity in science (Good, 72%), a result of inference, imagination, and human creativity (Good, 78%), socially and culturally embedded (enough, 65%), and the difference between observation and inference (excellent, 82%). Therefore, it is necessary to develop a learning strategy that balances the understanding of NOS, develop teaching methods that strengthen weak indicators, such as the relationship between theory and law and the socio-cultural context, investigate the factors causing variations in NOS understanding, and measure the impact of teacher candidates' understanding of NOS on the quality of science teaching in the classroom.

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