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Preservice Elementary-school Teachers' Perceptions about the Nature of Science

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Abstract: This study investigated the perceptions of elementary school preservice teachers in their 4th year at K-Education University, an elementary school teacher-training institution, on the nature of science (NOS). To examine the differences in elementary school preservice teachers' perceptions of NOS according to their high school career aptitude, we conducted in-depth interviews with two students each in the humanities and social sciences (HS) and natural sciences (NS) based on the subjects that they had taken while attending high school. For this purpose, we used the Views of Nature of Science Form C (VNOS-C) and Views about Scientific Inquiry (VASI) questionnaires, which were reconfigured. The main research results were that the elementary school preservice teachers showed a positivistic perspective on the NOS, validity of scientific knowledge, difference between theory and law, and social and cultural embeddedness of science. However, they had a latest perspective on the tentativeness of scientific knowledge, observation and inference, and the role of imagination and creativity. In particular, there were clear differences in perception between HS and NS teachers in the areas of tentativeness of scientific knowledge and understanding of observation and inference. Based on these research results, educational implications for improving the science education competencies of preservice elementary school teachers were proposed.

Keywords: Preservice Teacher, Elementary School, Nature of Science, Nature of Scientific Inquiry

I. Introduction

In many fields, there is now an emphasis on having the necessary literacy as a citizen to lead modern society and prepare for the future society. Science literacy is an essential ability that all members of society must have (AAAS, 1990, 1993), and its meaning extends to not only reading and understanding scientific issues but also expressing personal opinions (Miller, 1983). The latest meaning of scientific literacy is the basic ability to positively evaluate the value of science and technology and make rational decisions with the right values regarding various Socio-Scientific issues (SSI) related to science (Collette and Chiappetta, 1984).

OECD (2013) presents scientific literacy as the ability to participate in SSI and scientific ideas as a reflective citizen, the Korean science curriculum also defines scientific literacy as the ability to scientifically and creatively solve individual and social problems. and emphasizes scientific literacy education (MOE, 2015; 2022). There are various discussions taking place around the world regarding the development of science education to foster scientific literacy, and among them, Nature of Science (NOS, hereafter) education has been emphasized as one of the main goals of science education for the past 100 years (Lederman, 2007). Understanding the NOS is an important component of scientific literacy that improves understanding of scientific concepts and enables informed decisions about SSI (Driver et al., 1996; Roberts, 2007; Roberts and Bybee, 2014).

Osborne et al. (2003) broadly divide areas related to the NOS into the nature of scientific knowledge, scientific methods, and scientific institutions and social practices. The nature of scientific knowledge includes tentativeness, verifiability, integration, and so on,

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which are unique features of science that distinguish it from other disciplines. The area of scientific method, including experimentation, critical verification, and diversity of scientific methods, is related to the nature and basis of the process of constructing and justifying scientific knowledge and can be called the nature of scientific inquiry (Schwartz et al., 2008). While scientific knowledge deals with epistemological topics about the results obtained through inquiry, the nature of scientific inquiry deals with epistemological topics related to the process of inquiry.

Research on students' perceptions of the NOS began by Wilson in 1954, and since then, research on education on the NOS has been actively conducted, along with research examining the perceptions of not only students but also teachers (Irwin, 2000; Abd-El-Khalick and Akerson, 2004; Khishfe and Lederman, 2006; Deniz and Akerson, 2013; Erduran 2014).

Since it is effective to teach the NOS from the lower grades (Lederman and O'Malley, 1990), there is a need to more actively conduct research targeting elementary school students. In addition, teachers' perceptions of the NOS are reflected in their classes, and affect students' formation of scientific concepts (Gallagher, 1991). In this context, it is necessary to investigate how preservice elementary school teachers perceive the NOS and reflect this in the curriculum for teacher education to ensure that elementary school students have a correct understanding of science in the future.

However, compared with elementary and secondary school students or in-service teachers, there is a lack of research targeting elementary school preservice teachers (Lee et al., 2021), and in particular, little research has been conducted on the differences in NOS perception of preservice teachers according to their career path and aptitude while attending high school.

In the case of preservice elementary school teachers in Korea, far more high school students with aptitude for careers (career aptitude, hereafter) in humanities and social sciences enter teacher education colleges than those in natural sciences (Na and Yoon, 2020; Lee, 2023). Therefore, most preservice teachers have not completed advanced science electives in high school, and they experience difficulties in cultivating science content and inquiry competencies during the preservice teacher education process.

In addition, for Korean science curriculum, the number of science subjects completed and the level of achievement vary depending on career aptitude in high school, so it is necessary to provide education for preservice elementary school teachers by taking these differences in career aptitude into consideration (Lee, 2023). In this context, the purpose of this study is to investigate elementary school preservice teachers' awareness of the NOS and to examine whether there are significant differences depending on career aptitude in high school.

The research questions of this study are as follows:

First, how do elementary school preservice teachers perceive the NOS?

Second, are there significant differences in elementary school preservice teachers' perceptions of the NOS according to their career aptitude in high school?

II. Methods

The participants in this study were four preservice elementary school teachers enrolled in their fourth year at K-University of Education, an elementary teacher training institution in the central region of Korea. Considering the recent reorganization of the high school curriculum and the fact that students do not choose a field when attending high school, research participants were divided into humanities and social sciences (HS, hereafter) and natural sciences (NS, hereafter) career aptitude based on the science subjects completed in high school, and two participants were selected for each career aptitude. The research participants in the HS completed courses such as Life and Science, Convergence Science, and Life Sciences I, while the NS participants completed courses such as Physics I, Chemistry I, Life Sciences I, and Earth Sciences I, as well as more advanced courses such as Physics II, Chemistry II, and Life Sciences II.

To investigate elementary school preservice teachers' perceptions of the NOS, we conducted in-depth semi-structured interviews with two students from each of the high school HS and NS career aptitude in high school. For the interview, we used the Views of NOS Questionnaire Form C (VNOS-C) questionnaire, developed to reflect aspects of the NOS presented by Lederman et al. (2002). Based on the VNOS-C and combining it with the Views about Nature of Scientific Inquiry Questionnaire (Lederman et al., 2014), we reconstructed the interview questions. The VASI questionnaire was developed by Lederman et al. (2014) to more specifically reflect the Nature of Scientific Inquiry (NOSI) aspect included in the NOS. By combining the VNOS-C and VASI questionnaires, the order of the items was reorganized according to the NOS and NOSI domains that each item commonly reflected. Therefore, the questionnaire used in the study consists of 17 items, of which 3 items include 2-3 sub-items.

The interview questions consisted of a total of 8 areas, including 7 areas on the NOS and 1 area on the nature of scientific inquiry. The NOS consists of the areas of validation of scientific knowledge, tentativeness of scientific knowledge, difference between observation and inference, subjectivity of scientific knowledge, role of imagination and creativity, difference between theory and law, and social and cultural embeddedness of science (Table 1).

The interviews were conducted for about an hour each, divided into two groups by category, and all interview content was recorded and transcribed. The final codes were derived from the transcribed interview data through repeated comparisons between researchers, and these were used to analyze the perception patterns of research participants by area of the NOS.

In addition to the qualitative analysis, a semantic network analysis was conducted on the in-depth interview text. Semantic network analysis is a method of confirming the frequency and centrality of text, and is a method of quantitatively showing keywords and links between keywords appearing in text. Using this, it is possible to identify which concepts are distributed in the NOS areas, depending on preservice teachers' career aptitude, and the semantic connection structure of concepts.

In the semantic network analysis, data processing such as stop-words (adverbs, prepositions, etc.) processing, case unification, and punctuation removal were performed. using the python-based NLTK library. Afterwards, similar words were grouped together, and words such as education, teacher, and preservice, which were mentioned in their usual meaning, were removed. In the case of teacher educator PCK, 86 keywords with a frequency of 4 times or more were selected out of a total of 360 keywords and visualized

Table 1. Interview Questionnaire

NOS Areas	Items
Validation of scientific knowledge	Understanding the observable factual basis of scientific knowledge, including abstraction, the insubstantiality of scientific concepts, etc.
Tentativeness of scientific knowledge	Understanding the tentativeness of scientific knowledge
Difference between observation and inference	Understanding the logic of verification
Subjectivity of scientific knowledge	Understanding the subjectivity of scientific knowledge
Role of imagination and creativity	Understanding the role of imagination and creativity
Difference between theory and law	Understanding the meaning of laws, the difference between laws and theories, and the function of scientific theories
Social and cultural embeddedness of science	Awareness of the universality of scientific knowledge and the reflection of social and cultural values in science
The Nature of Scientific Inquiry (NOSI)	Method of scientific inquiry
	Purpose and structure of the experiment
	Validity of theories and studies based on observation

using gephi 0.9.4. In the case of teacher PCK, 61 keywords with a frequency of 4 times or more were selected and visualized out of a total of 285 keywords.

III. Results and Discussion

1. Validation of scientific knowledge

Preservice elementary school teachers' answers to what science is and what makes science subjects different from other subjects are as follows. The research participants were anonymously designated as HS for those in the humanities and social sciences, and NS for those in the natural science career aptitude.

HS1: Science is a subject that focuses on understanding and explaining certain phenomena.
HS2: Compared to other subjects, science subjects emphasize rational and logical aspects.
NS1: Unlike other subjects, science is a study that observes natural phenomena and explores the causes or principles of the observed natural phenomena.
NS2: Science is the translation of natural phenomena surrounding humans into human language so that humans can understand them. Unlike other subjects, science deals with natural things that were not created by humans.

The participants commonly recognized that science is based on observations and facts about phenomena. Compared to HS preservice teachers (HS1, HS2), NS preservice teachers (NS1, NS2) used terms such as 'natural phenomenon' and 'inquiry'. In particular, considering that NS2 expressed science as 'transforming natural phenomena into human language,' it appears that he is aware of the abstraction process of scientific knowledge to some extent. In other words, science is based on observations of the natural world, and the validity of scientific claims is ultimately determined through observation of phenomena (AAAS, 1990), and in the process, scientific knowledge is not based on actual natural phenomena but on our knowledge. It seems to be recognized that scientific knowledge is not an accumulation of observable facts, but rather involves abstraction (Lederman et al., 2002), as it is abstracted according to the characteristics of tools or interpretation through the senses.

To examine the perception of the abstraction of scientific concepts more specifically, we asked questions about how scientists define and confirm species.

HS1: I think species is a classification standard created by humans and is intangible.
HS2: I think it is just a standard for classifying various species. Species were initially classified based on morphological, anatomical, or functional similarities, but now, with the development of genetics or molecular biology, species can be classified at a more micro level. I think scientists are more than 90% sure what a species is because research has made it possible to distinguish species based on genetic similarities.
NS1: Species and karyotype are very closely related, and species can be divided according to karyotype. There will be many ambiguous parts in the process of analyzing karyotypes and classifying species according to criteria. For example, I think that a new species concept may be necessary in cases where mutations occur very frequently or when standards cannot be applied to some organisms.

HS2 and NS1 preservice teachers recognized that scientists are scientifically confident in the concept of species and that species can be defined based on directly observable data rather than abstract concepts. However, species were recognized as abstractions created by humans and a convenient standard for classifying things.

In short, in the case of HS2 and NS1, although scientists said they were scientifically confident in the concept of species based on the technological advancements of modern science and the precision of analysis techniques, they expressed somewhat contradictory views by mentioning the 'need for a new species concept.' This shows that a consistent view on the NOS is somewhat lacking.

2. Tentativeness of scientific knowledge

Regarding the tentativeness of scientific knowledge, preservice teachers responded that scientific knowledge can change and is not absolute.

HS1: I think scientific theories can change. As science and technology develop, things that humans did not know before may be discovered, and what we now believe to be normal science may later go beyond the scope of normal science and become untrue.

HS2: Science itself is a provisional answer to a certain fact. For example, just as people used to believe in geocentrism but now believe in heliocentrism, scientific theories change because science and technology continue to develop and it is believed that there are many things that we have not discovered.

NS1: Scientific knowledge changes. Scientific theories can always change because other evidence that was not discovered before, or errors in data or evidence that one believed to be correct, can be revealed later.

NS2: Scientific knowledge changes. Because natural phenomena continue to change, scientific theories also change, and I believe that scientific theories cannot imitate nature 100%. So, we will continue to change the theory to be as close to 100% as possible.

While HS1 and HS2 emphasized changes in scientific knowledge due to social and historical contexts and the development of science and technology, NS1 and NS2 explained the reasons for changes in scientific knowledge by focusing on the discovery of new evidence and changes in natural phenomena themselves. In other words, the preservice teachers were somewhat aware that all scientific knowledge, including facts, theories, and laws, can never be absolutely proven (Popper, 1963), and that scientific claims can change as new evidence appears or existing evidence is reinterpreted according to new theories or social changes (Lederman et al., 2002).

3. Difference between observation and inference

To explore preservice teachers' perceptions of the difference between observation and inference, we asked preservice teachers to select a dinosaur skeletal shape that scientists had inferred, why scientists made that inference, and what information they used to make that conclusion.

HS1: Scientists would have made that judgment based on previously discovered fossils or fossil reconstruction data discovered so far. In the case of dinosaurs and animals, they evolved in a way that was advantageous for survival, so from a biological perspective, individuals with long legs and short arms were advantageous for survival.

HS2: Based on the evidence and data collected by scientists, they would have drawn that conclusion because there is more evidence of dinosaurs walking on two feet.

NS1: Compared to present animals, most animals have stronger and thicker hind limbs than their front limbs, so scientists would have guessed that the skeletal form of dinosaurs would have been appropriate for having short forelimbs and strong hind-limbs.

NS2: Looking at today's animals, I think they would have considered whether the dinosaur could survive, such as if the hind limbs were shorter than the front limbs, if the center of gravity was well aligned, if organs and other things were in the right positions, and if they blended well with other bone tissue.

Interview participants cited biological structure and function, knowledge of existing fossils, and comparison with current animals as reasons why scientists inferred that the hind limbs were thicker and longer than the forelimbs as an appropriate dinosaur skeleton. Differences between HS and NS preservice teachers can be seen in the responses to this area. While HS preservice teachers provided justification for scientists' inferences based on existing fossils, i.e., the accuracy of collected evidence, NS preservice teachers recognized that by comparing dinosaur descendants and other present-day animals, scientists explain their conclusions in relation to currently accepted scientific knowledge.

Understanding the difference between observation and inference is essential to understanding key concepts in science (Lederman et al., 2002), and preservice teachers were somewhat aware that the validity of a theory can be confirmed by checking the consistency with current data through hypothesis inference even without necessarily conducting observations or experiments.

4. Subjectivity of scientific knowledge

When asked whether scientists would reach the same conclusion if the process of collecting data for a scientific question was the same, preservice teachers responded as follows.

HS1: Even if the same data is used, each scientist has different knowledge or values that he or she considers important, so there are differences in the interpretation of the data, and as a result, the same conclusions are not reached.

HS2: Depending on the direction of the research and the purpose of data collection, certain biased data may be collected. And even with the same data, different people interpret it in different directions, so they do not necessarily reach the same conclusion.

NS1: Even with the same research question, the conclusion varies depending on what data was collected. Additionally, even if the same data is provided to scientists, the conclusions may vary depending on the perspective of data interpretation.

NS2: Conclusions will also vary depending on the perspective from which the data is interpreted or the background knowledge of the scientists.

Preservice teachers commonly recognized that conclusions are drawn based on the scientist's subjective opinion. However, in the case of HS2 and NS1 preservice teachers, they responded that biased data was collected or that conclusions varied depending on the collected data, which implies the premise that if the data were the same, the same conclusions would be drawn. This perspective stems from the traditional view that scientific knowledge is absolute and unique, and can be seen as reflecting the erroneous perception that conclusions are automatically drawn from data (Han, Choi and Noh, 2012).

Preservice teachers recognized that scientific knowledge is influenced by scientists' thoughts and backgrounds, and that these background factors determine which problems scientists study, what they observe, and how they interpret their observations (Lederman et al., 2002).

5. Role of imagination and creativity

Preservice teachers recognized that scientists use imagination and creativity when conducting investigations to obtain answers to their research questions.

HS1: I think it is important for scientists to use creativity and imagination when conducting research. Scientists can use imagination and creativity not only when looking at a phenomenon and developing a tentative hypothesis, but also throughout the data collection, interpretation, and research process.

HS2: Scientists discover theories and certain laws out of curiosity, and researching them instead of taking things for granted is the basis of their creativity and originality. And if you think anew and design different experiments by setting up new research conditions and variables, you may come up with another solution and you can promote development in a new direction, so creativity and imagination is used to some extent.

NS1: Through exploration and experimentation, scientists discover things or principles that had not been discovered before and create new ideas. In the process, they use creativity and imagination because they have to think of things that previous people have not thought of.

NS2: When conducting research, scientists establish theories by experimenting and observing various conditions to resemble actual natural phenomena. Therefore, in the process of inquiry, scientists use their creativity and imagination.

In addition, regarding when scientists use imagination and creativity in the process of inquiry, preservice teachers responded that scientists use imagination and creativity throughout the research process, from setting research questions to designing and performing experiments, interpreting results, and drawing inferences and theories, based on an attitude of not taking everyday facts for granted.

6. Difference between theory and law

Examples of answers from preservice teachers regarding the difference between theory and law are as follows:

NS1: A theory is close to a hypothesis, and a law is a generalization beyond a hypothesis. Since 'law' is included in the law, there is a strong feeling that it is something that does not change, so the law seems to be a slightly stronger and unchanging truth.

NS2: A theory is a scientific explanation of a natural phenomenon in human language, and a law is a formalization of a theory explained in scientific language. For example, when Newton saw an apple falling to the ground, he discovered and organized that the Earth was pulling the apple with a certain force, which is the theory of universal gravitation, and formalizing this in a formula is a law.

Preservice teachers recognized theory and law as different types of knowledge, but were unable to clearly explain the difference between the two terms. NS1 preservice teacher recognized that a theory exists as a hypothesis, but a law goes beyond it, and that a hierarchy exists between the two terms. He was also confused between laws as social norms and scientific laws. The NS2 preservice teacher also defined a law as ‘a formalization of a theory’ and understood the law as a sub-concept of theory.

Preservice NS teachers recognized that drawing explanatory statements from observable phenomena was a law (Lederman et al., 2002). Preservice teachers recognized that there was a difference between theory and law in terms of explanatory scope, etc., but they had difficulty making a strict distinction.

7. Social and cultural embeddedness of science

The responses of preservice teachers regarding the social and cultural embeddedness of science are as follows.

HS1: I think social and cultural values should be reflected in science. Scientists do science not only to gain scientific knowledge, but also to use that scientific knowledge to change society into a more livable environment and live a more convenient life. And this is because science is not an independent form of knowledge, but influences and is influenced by other societies and such.

HS2: No matter what theories and laws contain the values of a particular scholar, science itself is a discipline based on very logical facts because they are the most influential facts currently proven. If this kind of study takes on social and cultural value, it may lose all its existing reason and logic, so science must be universal.

NS1: It is important for people from different societies or cultures to equally understand a phenomenon or scientific law. For example, a scientific principle discovered in India must be described so that it can be equally understood in the United States or Korea. Therefore, when sharing something about science, it is better to be universal rather than depending on social values.

NS2: Science is a discipline that discovers and explores natural phenomena in the most similar way, and human social and cultural values do not exist in the nature that science explores. Therefore, science must be universal at all times and at any moment.

HS1 recognized that science is not simply an objective, independent knowledge system, but must be developed and applied within a socio-cultural context. It was emphasized that scientific research topics can be determined according to social and cultural needs, and that science should contribute to improving society by reflecting social needs and values. In contrast, the other preservice teachers emphasized the universality of science and responded that science should not be corrupted by sociocultural values.

The HS2 preservice teacher emphasized that science should be maintained as a logical and fact-based discipline, and the NS2 preservice teacher also recognized that since natural phenomena themselves do not contain socio-cultural values, science should also be independent of these values. Meanwhile, NS1 preservice teacher emphasized universal understanding and sharing of scientific knowledge and focused on universality of expression. In short, the HS preservice teachers had a better understanding of the fact that science takes place in a cultural context as part of human activities and is influenced by various social and cultural structures, politics, economic factors, philosophy, religion, etc. (Lederman et al., 2002).

8. The Nature of Scientific Inquiry

First, regarding the nature of scientific inquiry, all research participants answered that questions are necessary as the beginning of inquiry. The preservice teachers recognized that questions are essential in scientific inquiry, that questions can arise from curiosity, and that inquiry methods can also vary depending on the scientific question.

HS1: Most scientific research begins with curiosity, interest, or questions. By asking questions, the experiment itself can become clearer, such as what I need to find out in this experiment and what I need to collect. Starting with curiosity, interest, or questions is important because it determines the direction of research.

HS2: Scientific research should always start with a question. Scientific inquiry begins with questions because what starts from simple curiosity or curiosity ultimately leads to questions such as ‘Why is this like this? Why does this phenomenon occur?’

NS1: You should have questions to use scientific inquiry methods in the process of finding answers to questions, and since that is research, scientific research must have questions.

NS2: Because scientific research needs a purpose to be established as science, it must start with a question to achieve that purpose.

Second, in order to gain an understanding of the scientific method, we asked questions about an investigation that observed birds several times and concluded that the shape of a bird's beak is related to the type of food, whether this investigation was scientific or an experiment. The responses of preservice teachers are as follows.

HS1: This investigation is scientific and an experiment because they developed a hypothesis, collected data, and analyzed the collected data to test the hypothesis. (…) Observation, experimentation, and investigation are methods of inquiry.

NS1: In this investigation, they set up their own hypothesis and did not use variable control in the hypothesis testing process, but I think the process of collecting and classifying various data is an experiment because it is a sufficient way to test the hypothesis.

NS2: I think it is an experiment because they explore the natural phenomenon of beak shape depending on the food birds eat, and through that, find the relationship between food and beak.

HS2: This investigation examines data and comes to a conclusion, but it is not an experiment because there is no hypothesis and no experimental setup to prove it. To be scientific, it usually requires a logical process based on reason.

The presented inquiry case can be said to be scientific in that it infers the relationship between variables through repeated observation (Han et al., 2012), but it did not use a method to control and adjust variables (Schwartz et al., 2008). The participants judged the case to be scientific, citing observation, data collection, classification, and reasoning processes, but were unable to clearly explain the requirements of the experiment, such as variable manipulation and control. In addition, they expressed the misconception that an experiment could be constructed through observation or data collection alone.

Meanwhile, the HS2 preservice teacher judged that the presented inquiry case was not scientific because no experiment was conducted, showing the view that scientific inquiry must use a specific method called experiment.

Third, in order to examine participants' perceptions regarding the validity of theories and studies based on observation, we asked whether they thought experiments were essential for the development of scientific knowledge.

HS1: Experiments are essential in the development of scientific knowledge. Without experiments, we would not have been able to discover the scientific knowledge we know today.

HS2: I think experimentation is necessary. For example, for cancer research, treatment, and other diseases or diseases, experiments are essential because the efficacy of the drug in question must be accurately known through experiments before it can be applied to people.

NS1: Ethicists and philosophers discover and create certain final knowledge through thought alone, but science must be conducted according to more objective and clear standards or methods than that. Whether it is scientific knowledge or not is determined by whether the right inquiry process is used. Therefore, experiments are essential for scientific knowledge to develop and be clearly recognized.

NS2: Experiments are helpful in advancing scientific knowledge, but I don't think they are always necessary. Scientific knowledge can also be developed by reducing errors with natural phenomena through observations or mathematical calculations.

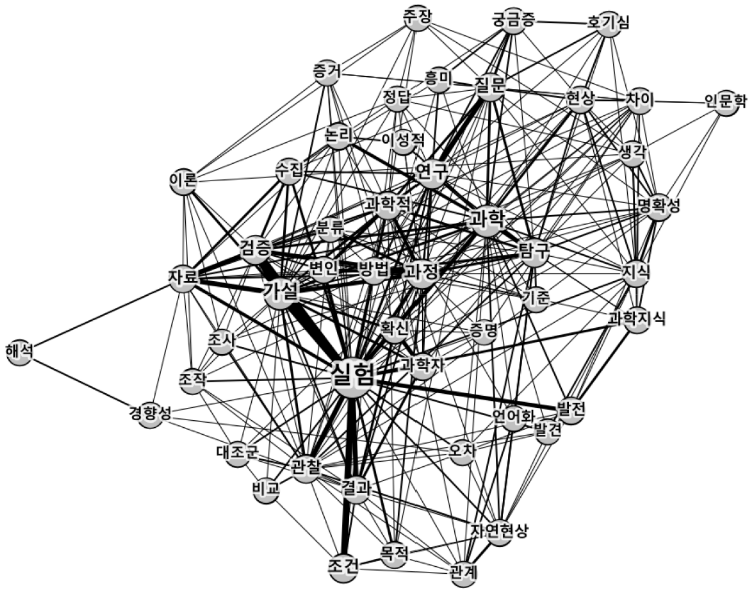
Three research participants responded that experiments are absolutely necessary for the development of scientific knowledge, and this seems to be the result of not fully recognizing the diversity of scientific inquiry methods. In contrast, NS2 preservice teacher was aware that there are various approaches to scientific inquiry. For example, in astronomy or geology, observation plays a more important role than experiment. Additionally, scientific discoveries are sometimes made through mathematical theories or logical reasoning.

In other words, experiments do not always play a decisive role in scientific inquiry, and hypotheses can be verified or laws derived even through non-experimental methods (Cho, 2020). However, it was found that preservice teachers lacked awareness of the roles of observation, mathematical modeling, and reasoning in addition to experiments.

The results of semantic network analysis for the preservice teacher's NOS are shown in Fig. 1.

In Fig 1, the size of the node indicates the frequency of keyword appearance, and the thickness of the connection reflects the frequency of connection between keywords. The semantic network analysis results are as follows:

The nature of scientific inquiry includes sub-domains such as scientific inquiry methods, the purpose and structure of experiments, and the validity of theories and studies based on observations. Therefore, in order to structurally examine the overall perception of elementary school preservice teachers on



keyword	freq.
Experiment	32
Hypothesis	15
Science	15
Research	11
Process	10
Testing	9
Inquiry	9
Condition	8
Question	8
Observation	7
Scientific	7
Data	6
Method	6
Scientist	5

Fig. 1. Semantic network analysis results for the preservice teacher's perceptions of NOS

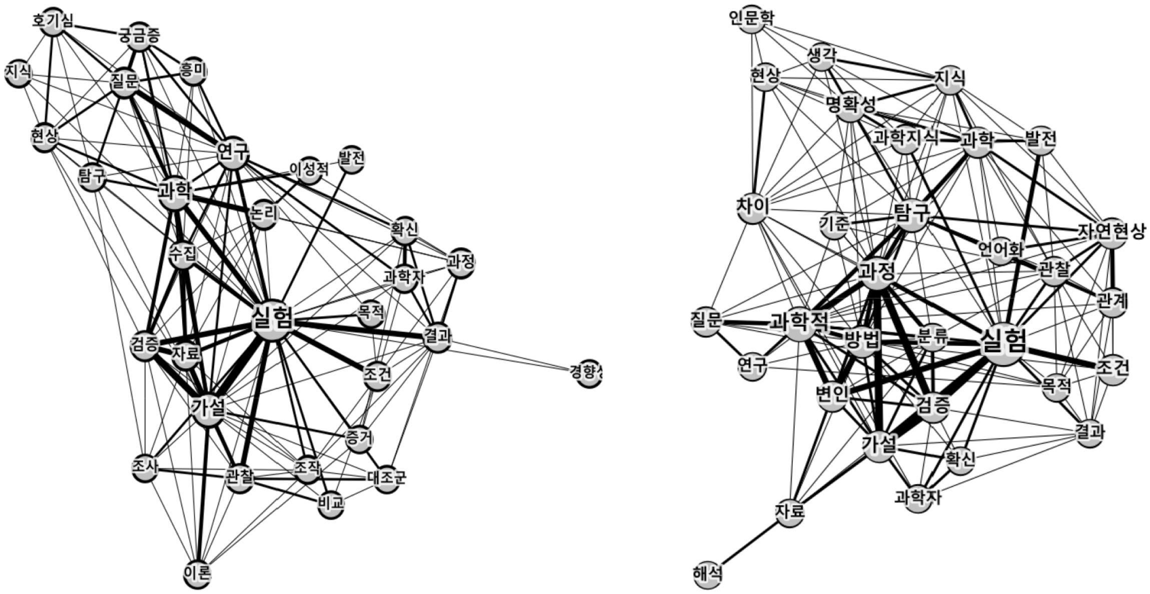


Fig. 2. Semantic network analysis results for the preservice teacher's perceptions of NOS: HS (left), NS (right).

this, we extracted major keywords and conducted network analysis.

The frequency of appearance of major keywords extracted from the responses of elementary school preservice teachers is shown in Fig. 1. In addition, keywords that appeared more than twice were visualized through network analysis (Fig. 1). 'Experiment', which has the highest frequency of keyword appearance, is located at the center of the network and is connected to major keywords such as hypothesis, research, process, verification, and condition.

Fig. 2 shows the results of the analysis by career aptitude. In all career aptitudes (HS, NS), keywords such as verification, data, and hypothesis are strongly connected to the keyword 'experiment'. In addition, in the HS response, the strength of the connection between the main elements related to the beginning of the inquiry, such as hypothesis, data, and 'collection', was high, while in the NS response, the connection with the main elements related to the inquiry process, such as verification, variables, and process, was strong.

By keyword, keywords such as curiosity, wonder, and interest appeared only in the responses of HS preservice teachers, whereas variables, natural phenomena, methods, and clarity were only confirmed in the responses of NS.

Ⅳ. Conclusion

In this study, we examined elementary school preservice teachers' perceptions of the NOS and explored differences according to career aptitude (HS, NS) in high school. Based on the research results, the following conclusions and implications were drawn.

First, elementary school preservice teachers had somewhat insufficient awareness of the areas of the NOS, such as the validation of scientific knowledge, the difference between theory and law, and the social and cultural inherent aspects of science. Regardless of career aptitude, preservice elementary school teachers generally lacked awareness that scientific knowledge is based on observable facts and that scientific knowledge is not simply an accumulation of facts but includes indirect observation and abstraction through tools. Accordingly, some preservice teachers failed to demonstrate a consistent understanding of the validity of scientific knowledge, such as expressing contradictory views on the same question.

Moreover, although preservice teachers recognized theory and law as different types of knowledge, they were unable to clearly explain the difference and recognized that a hierarchy exists between the two concepts. Regarding the social and cultural embeddedness of science, three out of four elementary school preservice teachers showed a positivist perspective on science by emphasizing the universality of science. In addition, while emphasizing the necessity of experiments in the nature of scientific inquiry, they failed to clearly explain the requirements of experiments or did not fully recognize the diversity of inquiry methods, expressing the traditional view that accurate scientific knowledge can be obtained through experiment-centered scientific methods.

In this context, it is necessary to improve the preservice teacher's awareness of the NOS through science education coursework in the preservice teacher education by providing explicit training and experience such as the process of forming scientific knowledge through simulation, comparison of Newton's laws of motion and Einstein's theory of relativity, and examples of scientific development in various cultures and times.

Preservice teachers showed a positivist perspective, and among them, differences according to career aptitude were evident in the areas of tentativeness of science, observation and reasoning. Regarding the changeable and provisional nature of scientific knowledge, HS preservice teachers believe that scientific knowledge can change in social and historical contexts, while NS preservice teachers claimed that scientific knowledge can change due to the discovery of new evidence or changes in the natural phenomenon itself. This difference in perception can be cautiously attributed to the difference in science subjects taken while attending high school. Because HS students are exposed to more curricula that deal with social and historical aspects, they are more likely to have the perception that science can change as a social construct. On the other hand, NS students are exposed to more curricula centered on scientific methodology and experiments, leading to the perception that scientific knowledge can be modified according to new scientific discoveries or changes in natural phenomena.

All participants had a relatively good understanding of the reasoning process of drawing logical conclusions based on observed data. However, there were differences in the preservice teachers' approaches to verifying their reasoning depending on their career aptitude. While HS preservice teachers value the accuracy and direct correspondence of specific, physical evidence from the past, such as fossils, NS preservice teachers focused on current living things and their characteristics, emphasizing relevance and theoretical consistency with current scientific knowledge.

Considering this, there is a need to provide opportunities for preservice teachers from different fields to cooperate and learn from each other, so that they can exchange, understand, and apply diverse perspectives in a convergent and integrated manner.

Meanwhile, since this study is a case study that interviewed four preservice elementary school teachers at a specific education university, it may be difficult to generalize the research results. Another limitation of this study is that we did not examine the experiences of preservice teachers in college courses related to the NOS and scientific inquiry, including courses taken at universities. Therefore, in-depth research is needed to determine how prospective elementary school teachers' perceptions of NOS differ depending on the science-related courses they have taken at colleges of education. Despite these limitations, the results of this study can be used to improve teacher training curricula in colleges of education to cultivate expertise in science education, including improving elementary school preservice teachers' awareness of NOS.

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