ORIGINAL ARTICLE

Pre-Service Primary School Teachers' Application of the Features of the Nature of Science to Socioscientific

Mehpare Saka

Trakya University, Edirne, Turkey

Abstract: *The purpose of this study is to determine which features of the nature of science pre-service primary school teachers refer to while making a decision on a socioscientific issue at the end of the explicit reflective nature of science education. For this purpose, an exploratory qualitative research design was used in the study. The research group comprised 77 pre-service primary school teachers in their third year of studies at a public university. The study was carried out within the scope of the "Science and Technology Teaching" course. As a data collection tool, the socioscientific scenario "Babies with Three Parents" was used. Content analysis and descriptive analysis were used to analyze the data. According to the findings of the study, pre-service primary school teachers have a good level of ability to use the features of the nature of science, the changeable nature of scientific knowledge, and the fact that it is based on observation and experimentation when deciding on a socioscientific issue. Furthermore, pre-service class teachers primarily used the subjectivity and creativity features of scientific knowledge as well as the features of observation.*

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***About the Author**: Mehpare Saka, Trakya University, Edirne, Turkey, E-mail: mehparesaka@gmail.com, ORCID: https://orcid.org/0000-0001-9730-8607*

***Correspondence to**: Dr. Mehpare Saka at Trakya University of Turkey.*

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Introduction

PRIMARY school pupils constantly ask questions, which is understandable considering their age. These abilities are considered to have a significant effect on the development of scientific inquiry abilities (Gormley & France, 2019). Primary school teachers, who have a significant impact on the development of this skill, should carry out the learning-teaching process in science, as well as many other areas of the curriculum, by knowing where, how, and when to lead the process. Teachers' content knowledge, pedagogical competence, beliefs and attitudes toward science, as well as students' knowledge and beliefs about science, all influence this process (Fitzgerald, 2012). Similarly, teachers' knowledge and perceptions regarding the nature and features of science, one of the fundamental subjects of science, have a significant influence on the students' learning processes. Teachers who view science as a compilation of absolute truths find it challenging to incorporate the qualities of scientific knowledge and the nature of science into their inquiry-based learning methodologies. As a result, science could be neglected in these classrooms or learning activities that do not include scientific inquiry might also be presented (Appleton, 2002). These conditions disrupt and disconnect student learning not only from other curricular areas, but also from the context of life experience. The application of socioscientific issues is a highly effective method for observing the implementation of the features of the nature of science. In this context, it is important to determine the skills of teachers, who are an important element in teaching, to use the features of the nature of science. In addition to being controversial, it is important to figure out how this information can be used in the decision-making process of a socioscientific issue that can have a big impact on our lives in terms of how we learn and teach.

For more than thirty years, the primary goal of scientific education has been to develop science literacy skills, and it has been highlighted that with the reforms implemented, science education should be carried out in a meaningful and practical way (Karisan & Zeidler, 2017). The main objective of science literacy is to enable individuals to acquire decision-making abilities through the application of scientific information and scientific thinking in everyday life (Roberts, 2007). In this context, socioscientific issues include real-life topics that will enable students to gain these skills practically. As is well known, socioscientific issues are inevitably included in many areas of our lives, such as health and technology. Incorporating socioscientific issues into the educational process has been widely used over the last three decades to facilitate the acquisition and use of 21st century skills such as critical thinking, analytical thinking, and decision-making. In addition to being controversial, socioscientific issues are subjects that involve different social domains, such as political, economic, and ethical, and specifically involve ethical and moral evaluation and decision-making process (Evagorou, Jimenez-Aleixandre, & Osborne, 2012). Many contentious subjects, such as GMOs, nuclear power plants, vaccine research, and cloning, fall under the category of socioscientific issues. We have been confronted with these difficulties, which involve moral and ethical issues, particularly in recent years (Espeja and Lagarón, 2015). It is crucial for students to encounter real-world challenges in developing their decision-making skills by using the scientific knowledge they have learned (Osborne, 2008, Gomley et al., 2019). One of the primary purposes of education is to enable students to apply their conceptual knowledge in different contexts (Khishfe, 2013, De Corte, 2003). The use of socioscientific issues in the lessons also enables students to develop scientific literacy and positive attitudes towards science (Gomley et al., 2019; Hodson, 2013; Zeidler, 2014). In socioscientific issues, teachers should be able to effectively use science and nature of science concepts to enable students to engage in effective decision-making processes, as well as to structure and analyze presented arguments (Pezaro et al., 2014).It is well known that incorporating socioscientific issues into science education helps students have a better knowledge of science topics, improve their argumentation abilities, and comprehend the nature of science (Levinson, 2006; Zeidler & Sadler, 2008; Zohar & Nemet, 2002; Khishfe & Lederman, 2006).

In general, NOS includes scientific epistemological beliefs and beliefs of individuals about NOS knowledge, as well as some assumptions besides the distinctive features of scientific knowledge (Lederman, 2007; Hofer & Pintrich, 1997). In this regard, it is essential to observe pre-service primary school teachers' capacity to apply the nature of science to a socioscientific issue that is both debatable and scientific.

Recently, there have been numerous research studies in the field of socioscientific issues, which is an effective area that contributes to the growth of science literate individuals and should be appropriately included in science education programs (Hofstein et al., 2011; Sadler, 2003; Topçu, 2008; Walker & Zeidler, 2007; Zeidler & Keefer, 2003; Zeidler et al., 2005). According to studies, socioscientific issues can help students contribute to decision- making on local and global issues, understand the features of the nature of science, and gain experience in discussing controversial issues (Lee et al., 2013). Moreover, solving problems related to a socioscientific issue will encourage students to use scientific knowledge, and socioscientific issues in science education can be a tool to increase the priority of civic goals (Lee et al., 2012).

Studies on the relationship between SSI and NOS primarily focus on how the nature of science is used in the decision-making process of socioscientific issues (Bell & Lederman, 2003; Khishfe, 2012; Sadler, 2009). Over time, research on teaching the nature of science in an SSI setting has begun to be conducted from a variety of approaches. The majority of studies on the development of understanding of the nature of science using SSI applications have found that understanding of the nature of science has improved (Walker & Zeidler, 2007; Zeidler et al., 2011). However, it has been observed that SSIs are insufficient in conveying the features of science into the discussion and decision-making processes (Han Tosunoğlu & İrez, 2019).

In order to realize the reasoning and decision-making process, which is the most important goal of socioscientific issues, individuals must master the principles of scientific knowledge and scientific thinking. The significance of understanding the nature and features of science emerges, particularly in determining whether the information presented is scientific or not. Another cognitive condition, students' views on the nature of science (NOS), or scientific epistemological beliefs, was highlighted in a literature review on socioscientific decision-making (Sadler et al., 2004; Schommer-aikins & Hutter, 2002).

All science education programs that accept scientific literacy as a basic component emphasize providing students with information on the nature of science, such as the changeability of scientific knowledge that forms the basis of scientific studies and the fact that scientific knowledge is based on observation and experimentation (NGSS, 2013; NRC 1996; ACARA 2014). In our country, the concept of science literacy, which was first introduced in the 2005 science curriculum, is now one of the general targets in the curriculum since 2013. Furthermore, the 2018 curriculum included "Developing reasoning ability, scientific thinking habits, and decision-making skills through the use of socioscientific issues" (MEB, 2019). At this point, science literate individuals must gain awareness of current events affecting their society and have scientific thinking abilities when expressing their opinions on potential solutions to society's problems (Çalık & Coll, 2011). Looking at the main objectives of the 2018 science curriculum, it is seen that emphasis is put on individuals having the necessary skills to come up with solutions to possible problems that they may encounter in their daily lives (MEB, 2018). The program aims to teach students about NOS and to help them develop decision-making skills related to SSI throughout the entire science teaching program, starting from primary school. However, one of the most important issues that should not be ignored here is that teachers and pre-service primary school teachers have these knowledge and skills. When we look at the studies conducted in our country, it is seen that there are no studies involving primary school teachers, whereas studies involving pre-service primary school teachers try to determine their level of knowledge and opinions about both the nature of science (Akgün, 2015; Ateş & Öner, 2020; Taşdere et al., 2014) and socioscientific issues (Küçükaydın, 2019; Öztürk et al., 2018).

This research is significant in this context since it attempts to determine the ability of pre-service primary school teachers to transfer the features of the nature of science to socioscientific issues, as well as their questioning skills. In this regard, the problem statement of the research is as follows: "How do pre-service primary school teachers who receive explicit reflective nature of science education make use of the features of the nature of science while making a socioscientific decision?"

Method

In this study, an exploratory qualitative research design was used to address the research problem. The purpose of this study was to determine whether NOS education, as well as acquired knowledge and skills, was applied to a SSI with a randomly selected group of pre-service primary school teachers. While exploratory qualitative research allows researchers to get more detailed information about the study group (Kathlke, 2014), it also better explains people's feelings, thoughts, approaches, or beliefs (Percy et al., 2015).

Participants

The study was conducted with pre-service primary school teachers in their third year of study at a state university. The study group consisted of students enrolled in the two-semester "Science and Technology Teaching" course. The research group consisted of 77 participants in total, with 63 female and 14 male pre-service primary school teachers. Participants are between the ages of 20 and 22. Prior to this academic year, the participants completed science subject knowledge enhancement courses (basic physics, basic chemistry, and basic biology), science teaching laboratory applications, pedagogy courses (education psychology, education philosophy), methodology, and assessment and evaluation courses.

Data Collection Tool

In order to determine how pre-service primary school teachers use their skills on the nature of science in socioscientific issues, debate scenario titled "Babies with three parents" was presented within the scope of the research. The scenario includes a study on mothers with defective mitochondria to have healthy children by receiving healthy mitochondria from another mother. Although very few studies have included healthy babies, there is no conclusive result; instead, they provide the views of scientists on the possibility of having unhealthy babies due to the transmission of mitochondria from the mother. Along with the scenario, several questions are asked to pre-service teachers in order to elicit their thoughts on the issue. The following are some examples of questions about the scenario.

- Do you agree with this recommended approach to preventative medicine?
- Explain the reason for your decision.

- What finding or findings might change your decision?
- Do you think there is disagreement among scientists?

The preceding questions are based on Khishfe's (2012a) and Zeidler, et al.' (2002) approach that the nature of science is related to socioscientific issues, as well as the changeable nature of science, the experimental nature of science, the creativity and imagination of scientific knowledge, and the subjectivity of scientific knowledge. As a result, the purpose of this study was to ascertain pre-service primary school teachers' application of the features of the nature of science described in the given scenario.

Data Collection

The research lasted two semesters and 12 weeks and was conducted within the framework of "Science and Technology Teaching" (**Table 1**). At the beginning of the implementation process, the history and importance of science teaching programs were emphasized. Then, the teaching methods and techniques used in science education were taught practically. After introducing the constructivist approach that underpins the science curriculum, the 5E instructional model was introduced and practiced with pre-service teachers. The features of the nature of science were figured out in the process through the activities of the explicit-reflective nature of science. In this context, the activities prepared by Yalaki (2016) were used. Additionally, the researcher prepared and implemented the teaching process using the 5E instructional model to ensure that pre-service primary school teachers could better understand the 5E instructional model. After instructing pre-service teachers on the nature of science, they were asked to prepare lesson plans according to the 5E instructional model. While preparing the 5E lesson plan, it was stated that the pre-service teachers should plan with the features of the nature of science in mind.

Data Analysis

In the analysis of the answers given by the pre-service primary school teachers about the scenarios presented, criteria were created within the framework of descriptive analysis. The nature of science, the changeable nature of scientific knowledge, the reliance of scientific knowledge on observation and experiment, the subjectivity of scientific knowledge and creativity, and the use of observation and inference differences in the given scenario were all evaluated using the criteria developed. As shown in **Table 2**, the perceptions fell into three categories: sufficient (knowledgeable), inconsistent, and weak. If a participant did not mention the nature of science while expressing their opinion, they were evaluated as weak; if they expressed the features of the nature of science, but they did not provide a sufficient explanation, they were

Table 1. Teaching Process.

Weak	Teaching Process
Weak 1	Purpose and importance of science teaching
Weak 2	History of science curriculums
Weak 3	Information about the constructivist approach
Weak 4-5	What is the 5E instructional model? Which steps are important and why?
Weak 6-7-8-9-10	Nature of science teaching based on explicit reflective approach integrated into unit outcomes Heat and temperature: Observation and inference are different things. · How does light travel? Observation and experimentation are the foundations of scientific knowledge. · Let's classify living things: Scientific knowledge depends on imagination and creativity. · Environmental pollution (Which of us is more expert?): Scientific knowledge is affected by social and cultural structures. · Is the orientation geocentric or heliocentric? Scientific knowledge is changeable. · Footprints: Scientific knowledge is subjective. · - The structure of scientific theories and laws and their interrelationships.
Weak 11- 12	5E lesson plan writing (pre-service class teachers)

Table 2. Creative and Imaginative Nature of Scientific Knowledge.

Theme	Explanation
Sufficient (Knowledgeable)	Stating that imagination and creativity can be used at every stage of scientific studies together with justifications
Inconsistent	Stating that imagination and creativity can only be used at certain stages of scientific studies
Weak	Expressing that while imagination and creativity are used in the design and planning stages of scientific studies, they are not used in data collection, analysis, and interpretation

Table 3. Pre-service Primary Teachers' Decisions and Justifications on the SSI.

Opinions	f		Justifications	f	%
I am in favor	15	19.4	The probability of having a healthy baby	10	66.6
			The results obtained are sufficient	5	33.3
I am against	26	33.7	Uncertainty/There are no definitive results	19	73.0
			It causes negative consequences	5	19.2
			There is no legislation	1	3.8
			Insufficient explanations	1	3.8
			It is not ethical	1	3.8
I'm undecided	36	46.7	Uncertainty/Insufficient evidence/Inconclusive results	25	69.4
			It is risky/ There is no guarantee	8	22.2
			The studies are very new.	1	2.7
			It is not ethical	1	2.7
			Evaluation from different perspectives	1	2.7

evaluated as inconsistent; if they made reference to the nature of science while providing a sufficient and correct explanation, they were evaluated as sufficient (knowledgeable).

Additionally, the content analysis method was used to examine if respondents approved of the treatment procedure in the particular scenario. The content analysis method was used to determine the codes based on the categories generated in this way. Analyses were also carried out by another field expert besides the researcher. The researchers conducted the analyses independently at first, and then collaborated to complete the analysis until consistency between the analyses was achieved. While organizing the data analysis findings, sample quotations from participants are provided.

Findings

This section contains analysis findings on how pre-service teachers apply certain features of the nature of science to their decision-making processes when confronted with specified socioscientific issues. **Table 3** shows the pre-service teachers' responses to the question of whether they support the treatment and the rationales they employed in their thinking processes.

As shown in Table 3, the majority of pre-service teachers expressed that they were undecided (46.7%) about this treatment method. The reason for this hesitancy is seen to be the inadequacy of the study results (69.4 %), the inadequacy of data, and the uncertainty around the likelihood of being ill. Along with the procedure being risky (22.2%), the fact that the investigations were still in their infancy was cited as another justification. Below are sample sentences reflecting the views of pre-service teachers.

> *"I am undecided because there is no certainty. It is unproven information, it has good sides and bad sides. And that makes me indecisive."*
>
> *"I'm indecisive because it's scary to choose between having or not having children because of defective mitochondria, and the fact that defective mitochondria continue to be handed down to girls even if they recover. .... I can't decide as there is no clear data. It can also inherit other traits, such as intelligence, physical characteristics of the parent with healthy mitochondria. This is also a risk."*

It was also noted that pre-service teachers who were against the treatment most frequently cited a lack of conclusive results (73%). Additionally, several pre-service teachers expressed concerns about the potential negative outcomes (19.2%) and the absence of legal regulations (3.8%). Below are sample sentences reflecting the views of pre-service teachers.

> *"I disagree because this modification does not provide definitive data on disease prevention. It can lead to a result that is not ensured."*
> *"Because I think mitochondria damage will occur again in future generations. Also, two different DNAs seem to affect the whole cell structure. It may result in worse outcomes."*

It was determined that the pre-service primary school teachers who were in favour of the treatment and expressed a positive opinion were in the minority (19.4%). It is evident that pre-service teachers who agreed emphasize the likelihood of having healthy babies (66.6%). Additionally, it was revealed that some pre-service teachers stated that the study's findings were sufficient (33.3%). Below are sample sentences reflecting the views of pre-service teachers.

> *"Yes, I agree; it can be a dangerous situation. However, the alternative is also dangerous and can result in disorders. As a result, I propose to give the opportunity to attempt to those who desire."*
> *"Because the birth of a child with a disorder would have a negative impact on both the child and the family. The absence of a disease,so far,was also important when I made my decision"*
> *"If a woman is likely to have a healthy child,even if there is a low probability,she should give it a try."*

It was observed that only two of the participants evaluated the treatment by addressing the ethical dimension of socioscientific issues as inappropriate.

When the use of the experimental nature of scientific knowledge in socioscientific decision-making processes was examined, it was observed that most pre-service teachers were at the most knowledgeable level (**Table 4**). Therefore, it is seen that most of the pre-service teachers consider experiments and observations in their decision-making processes.
As shown in **Table 4**, the group with inconsistent structure (35 percent) was ranked second, as pre-service teachers considered experiment and observation in their decision-making processes but were inadequate in explaining in depth. It is seen that the weak group, which does not take into account the experiment and observation in the decision-making processes, constitute the smallest (27.2%) group.

Table 5 shows the frequencies at various levels and examples of the responses participants provided about the use of socioscientific issues in the decision-making process regarding the changeable nature of scientific knowledge.

Table 4. Pre-service Primary Teachers' Use of Experimental Nature of Scientific Knowledge in Reasoning Processes on Socioscientific Issues.

Theme	f	%	Example sentences
Knowledgeable	29	37.6	· If the researches are completed and reach a definite conclusion, scientifically proven and data are presented, my decision may change. · If this hypothesis is proven and generalized through experiments and observations, my decision may change. · As a result of the experiments and observations, if the genetic modification of the embryos does not cause any incompatibility problems, if it is proven that they will have characteristics like other children, or if a certain rate is obtained against the damage, I could be in favor of it.
Inconsistent	27	35	· My opinion may change if it is determined that a child born with the mitochondria of the two women will be one-hundred percent healthy; however, this claim must be supported with solid evidence. If there is a certainty that the children born with the mitochondria of two women will carry the mitochondrial disease to the next generation and the findings are robust, my decision may change. · The fact that (the baby) is genetically related to only one of the two women can change my opinion or the assurance that the baby will be healthy can change it. The fact that faulty mitochondria can be found in the ovaries of all girls and may be transmitted to the next generation may change if new findings become available.
Weak	21	27.2	· An increase in miscarriage raters and an increase in mitochondrial disorders in subsequent generations change my decision. · There is no assurance that children with two different genes, except for the father's, will be healthy, and all girls pass on the genes from generation to generation.

Table 5. Pre-service Primary Teachers' Use of the Changeability of Scientific Knowledge in Reasoning Processes on Socioscientific Issues.

Theme	f	%	Example sentences
Knowledgeable	27	35.5	· It can change. If much more research has been done) on this subject and more precise data is reported, my decision may change. · Research can be scientifically proven. · My decision can change if the results of experiments in long-term studies are mostly positive, that is, if mitochondrial incompatibility does not occur.
Inconsistent	36	47.3	· If it is proven that the defective mitochondria of the mother are not transferred to the ovaries of her children when the defective mitochondria are replaced, and if a method can be developed to ensure that the babies do not receive genes from two different women, but only the mother's, my decision may change. · My decision may change if the results show that one has been considerably healed, that it has not been handed down to subsequent generations, or that the negative qualities of the person whose healthy mitochondria will be used, will not be passed down to the newborn individual.
Weak	13	17.1	· I believe there are no findings or findings that can change my mind about this since, while it is a disorder that has not occurred previously, it is not certain that such a circumstance will not develop in the future.

Table 6. Pre-service Primary Teachers' Use of the Subjectivity of Scientific Knowledge in Reasoning Processes on Socioscientific Issues.

Theme	f	%	Example sentences
Knowledgeable	25	32.4	• The reason for their difference of opinion is that they look at it from different angles, each defending what is right in his own view. • But the center of his ideas is the same experiment and results. • The researchers make decisions and produce ideas based on their own knowledge, influenced by their social and cultural context, and based on their level of expertise on this subject. They generate ideas by adjusting them to their own subjective judgments based on the results of their experiments and studies. There may also be disagreement because scientific knowledge is subjective.
Inconsistent	18	23.3	• Since the two opposing viewpoints are so strong, they cannot be refuted. Disagreements emerge when scientists advocate for what is more correct from their own point of view. • One group aims to eliminate chronic disorders from the start, whereas the other group examines the negative consequences. Both groups approach the problem from different angles. • Because both sides approach the same method from different perspectives.
Weak	34	44.1	• Because there are still risks. There may not have been any problems in the two test subjects. However, other experiments may find problems. In addition, the mitochondrial gene has an increasing importance day by day. Is it ethical (for an individual) to carry the genes of two different women? I think scientists are divided because of these reasons. • Because it is not stated that they would never develop disorders. There is a chance, and a human with someone else's genes and the increasing effects of these genes may have split them in two. • Because they are still unsure, it is also explained in the paragraph.

When the answers of the pre-service primary school teachers were examined, it was discovered that the majority of them (47.3%) fell into the inconsistent category, meaning that they considered the changeability of scientific knowledge in the decision-making processes of the socioscientific issue, but their explanations were insufficient. It can be seen that pre-service teachers who could provide appropriate explanations regarding the changeable nature of scientific knowledge rank second (35.5%).The number of pre-service teachers who were unable to employ the changeable nature of scientific knowledge in the decision-making process of the socioscientific issue was the smallest in the group (17.1%).

When the responses provided by pre-service teachers to issues about the varying views of scientists while making decisions on socioscientific issues are analyzed, it is discovered that they mostly have a poor level of knowledge (44.1%) and are unable to explain the subjective nature of scientific knowledge (**Table 6**).

According to the analysis, some pre-service teachers (55.7%) who used the subjectivity of scientific knowledge in the decision-making process of SSIs were in the knowledgeable group (32.4%), and they explained the difference between observation and inference (the subjectivity of scientific knowledge), and imagination and creativity.

Discussion, Conclusions, and Suggestions

According to the research findings, the majority of pre-service primary school teachers claimed that they were indecisive or against making decisions in the given socioscientific issue. The most significant finding is that pre-service teachers emphasize the inadequacy of the information or studies presented in decision-making processes. Therefore, it can be stated that pre-service teachers have the skills to apply scientific knowledge to everyday issues.

It is seen that pre-service teachers have generally a good level of knowledge when it comes to utilizing the nature of science as being based on observation and experimentation, which are the most basic features of the nature of science, in the decision-making processes of the socioscientific issue. Considering the results in **Table 2** and **Table 3**, it can be said that the majority of pre-service teachers use the experimental nature of scientific knowledge in their decision-making processes regarding socioscientific issues. Similarly, Zeidler et al. (2002) noted that owing to the nature of science education, provided to pre-service high school and science teachers through explicit-reflective argumentation education, pre-service teachers were able to reflect the experimental nature of scientific knowledge in their evaluation procedures for socioscientific issues. In addition, although some studies have shown that pre-service class teachers develop views on the nature of science, there are also research results in which they make judgments about socioscientific issues that are not supported by evidence, rely on irrational thinking, or are founded on assumptions (Alker & Zeidler, 2007). Another research involving pre-service primary school teachers discovered that some pre-service teachers make unscientific claims about socioscientific issues. Additionally, pre-service class teachers who made scientific claims provided insufficient proof and reasoning (Pezaro et al., 2014). Such results support the notion that pre-service primary school teachers may influence their future pupils to assert their claims that are not supported by scientific evidence.

Again, according to the findings, the majority of pre-service teachers reflect the changeable nature of scientific knowledge to decision-making processes in the socioscientific scenario, which is consistent with the findings of other studies (Matkins & Bell, 2007; Sadler et al., 2004) in which the changeable nature of scientific knowledge is used in decision-making processes on socioscientific issues.

According to the findings of this study on the ability to utilize the subjective structure of scientific knowledge in the socioscientific issue, pre-service primary school teachers refer to the subjectivity of scientific knowledge at the lowest level in the decision-making process of SSIs. Considering the relationship between understanding the nature of scientific knowledge and reasoning on socioscientific issues, individuals must accept that scientists' suggestions can be significantly influenced by the fact that science contains correct or incorrect information, especially due to differences in imagination and creativity. Additionally, while scientists defend their arguments, they should embrace the debates that result from divergent views as natural and justify this with the subjectivity of scientific knowledge (observation-inference difference) as well as imagination and creativity. Studies have shown that the reasoning quality of the students increased in the analyzes based on experiment and observation (Wu and Tsai, 2011), and students who accept the changeable nature of scientific knowledge develop skills such as understanding complex contexts, approaching issues from different perspectives, and questioning authority (Liu et al., 2011). These results reveal that the features of the nature of science are important in the development of students' skills such as decision-making, questioning, and evaluation, and that these skills should be acquired by both students and teachers and pre-service teachers, who are essential elements of education.

Additionally, when individuals perceive, evaluate, and make decisions on contradictory situations in a socioscientific context, their beliefs, interests, and social circumstances are influenced by a variety of factors relating to the nature of science (Sadler et al., 2002). In this context, it can be interpreted as a significant finding that the majority of pre-service primary school teachers made decisions in socioscientific issue evaluations by considering the changeable nature of scientific knowledge, which is based on experiment and observation, creativity and imagination, observation and inference. Furthermore, studies have shown that long-term learning contexts in which the planning of teaching the nature of science in a clear and reflective manner, as well as learning environments with rich content in which the nature of science is reflected in a variety of different contexts, could effectively develop pedagogical content knowledge regarding the nature of science (Akerson et al., 2017; Wahbeh & Abd-El-Khalick, 2014).

This study indicates that pre-service primary school teachers who receive explicit reflective nature of science education can effectively apply the features of science, particularly the changeable and experimental nature of scientific knowledge, to the evaluation and decision-making processes for a socioscientific issue. Additionally, approximately half of the sample group incorporated the creative and imaginative features of scientific knowledge, as well as the subjectivity of scientific knowledge, into their decision-making processes. When these findings are compared to the literature, it becomes clear that in order to make a greater contribution to science education, additional research on the effect of explicit reflective NOS practices on primary school students at different grade levels and on the level of transferring this to socioscientific issues should be conducted in the future. Additionally, the study can be conducted with primary school teachers, to assess their current situation and to conduct evaluations on socioscientific issues, as well as other studies on applications for the advancement of the NOS. Furthermore, more detailed studies can be designed on how primary school pupils, the main target group, can be affected by the work to be done with primary school teachers. Thus, it is possible to ensure that the effect of the teacher factor on the decision-making processes of primary school pupils on SSIs, as well as the NOS education addressed in the programs, can be monitored.

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