Higher Education Studies; Vol. 12, No. 3; 2022
ISSN 1925-4741 E-ISSN 1925-475X
Published by Canadian Center of Science and Education

Educational Philosophy Adopted by Pre-Service Science Teachers

Oktay Bektaş[1]

[1] Erciyes University, Faculty of Education, Mathematics and Science Education Department, Kayseri, Turkey

Correspondence: Oktay Bektaş, Erciyes University, Faculty of Education, Mathematics and Science Education Department, Kayseri, Turkey. Tel: 90-352-207-6666. E-mail: obektas@erciyes.edu.tr

Received: May 13, 2022 Accepted: June 18, 2022 Online Published: June 20, 2022

doi:10.5539/hes.v12n3p47 URL: https://doi.org/10.5539/hes.v12n3p47

Abstract

This study aims to examine the thoughts of fourth-year pre-service science teachers about the nature of science. For this purpose, the study preferred the qualitative research method and phenomenology design. Participants consisted of nine pre-service science teachers. Participants wrote a self-evaluation report after the nature of the science course. I collected data with this report and focus-group interview. I did the data analysis using content analysis. The current study discusses validity and reliability. As a result of the analysis, pre-service science teachers stated that they learned the nature of science by adopting the constructivist philosophy. Therefore, they described that they will use the constructivist scientific language when they become teachers in the future. They argued that students should learn how scientific knowledge changes and develops. In addition, pre-service science teachers emphasized that teachers should direct their students' learning processes according to the constructivist philosophy considering scientists' culture, beliefs, and prior knowledge. They stated that students should understand the socio-cultural impact on the learning process. They also mentioned that students should use their imagination and creativity so that they can learn scientific information meaningfully. Based on these results, I suggested that teaching based on positivist philosophy would not remove the obstacles to students' learning science.

Keywords: constructivism, positivism, pre-service science teacher, philosophy

1. Introduction

Positivism wants to reach absolute truths (Comte, 2015). For this reason, it focuses on the result and cares about the formation of scientific knowledge through numbers. It defends that scientific knowledge should be absolute and adopts it to be universal (Kolakowski, 1993). When these features of positivism are used by teachers, students focus on the result in the learning process and do not care about the development process of scientific knowledge. Therefore, students learn by rote instead of meaningful learning (Mayer, 2002). On the other hand, a positivist-based learning process causes students to ignore the scientist. Because students focus on the result, they do not focus on the role of the scientist in the process. Thus, students cannot display a positive attitude like being a scientist and always consider scientists as unreachable people. To remove these barriers to students' learning, the constructivist-based nature of science teaching becomes important in the learning process of students (Knowlton, 2000). Constructivism adopts students to take an active role in the learning process and construct their new knowledge by using their prior knowledge (Fosnot, 2013). Constructivism focuses on the process rather than the outcome of the learning process. Therefore, constructivism cares about the development process of scientific knowledge and the role of scientists in the development process of scientific knowledge. From this point of view, if teachers focus on the process rather than the result in the learning process, they can enable students to learn meaningfully. Therefore, teachers need to adopt constructivism as a philosophy.

Why can't teachers get rid of the influence of positivism? Why do they prefer result-oriented positivism instead of constructivism, which is a student-centered philosophy? These questions can have many answers. One of the most important answers is about the system. Where students are accepted from middle school to high school and from high school to university through a multiple-choice examination system, teachers accept positivism as a philosophy. A multiple-choice assessment system asks students to choose a single answer. In other words, this system, like positivism, seeks to reach absolute reality (Dickerson et al., 2008).

Turkey is one of the countries that use the multiple-choice assessment and evaluation system. With this system, teachers have to educate students competitively rather than cooperatively. In a competitive environment, teachers prefer to give scientific knowledge directly instead of the development process of scientific knowledge. In this system, it doesn't matter what the chemical change is, why it happens, how the chemical change happens, and which scientists study it (Ardac, & Akaygun, 2004). Such a system allows the student to choose only one thing. Therefore, students also focus on the result and do not care about the learning process. This system prevents students from solving problems, thinking critically, analyzing, and being creative (Haladyna, 2004).

To solve these problems for students, Lederman (1992). stated that the development process of science should be understood by the students. Although researchers state that the debate on the definition of the nature of science continues, Lederman (1992) defined the nature of science as the epistemology of science, science as a way of knowing, or scientific knowledge and values and beliefs about its development. Thus, the dimensions of the nature of science proposed by Lederman (1992) have taken their place in the literature. According to these dimensions, students can think scientifically and evaluate scientific events. Also, if students can make sense of these dimensions, their problem-solving, critical thinking, and creative thinking skills will improve (Lederman & Lederman, 2014).

Abd-El-Khalick & Lederman (2000). stated that it would not be appropriate for students to teach science by considering positivist philosophy. Therefore, they stated that constructivist philosophy should be taken into account in the learning process of the student. From this point of view, they stated that scientific knowledge can be changed and developed. In addition, they emphasized the importance of experiments, observations, and logical inferences in the development process of scientific knowledge. They also stated that the role of the scientist in the development process of science should not be forgotten. They mentioned the students should gain the persistent, stubborn, and curious nature of scientists. They said that the belief, culture, and prior knowledge of the scientist should be taken into account in the development process of scientific knowledge (Lederman et al., 1998).

So far, I have explained that teachers should adopt a constructivist philosophy for their students to realize meaningful learning in the learning process. At this point, the education of pre-service science teachers should also be examined (Adal, & Cakiroglu, 2022). As they will be the teachers of the future, pre-service science teachers must also have an educational philosophy. This philosophy, as I explained above, should not be a positivist philosophy. It should be essential to educate pre-service science teachers who adopt the constructivist philosophy (Uzuntiryaki, et al., 2010). From this point of view, this study investigated the extent to which preservice science teachers adopted this philosophy and shed light on them by increasing their awareness so that they can raise students who can think scientifically. Based on this reason, the research question of the study is as follows: What kind of educational philosophy do pre-service science teachers adopt in the process of teaching scientific knowledge?

2. Method

2.1 Design of the Study

This study adopts the qualitative research method. I have used phenomenology as a design. Phenomenology is a design that studies people's experiences (Laverty, 2003). I have employed Van Manen's (2007) hermeneutic phenomenology model in this study. Thus, I have tried to interpret the philosophical understandings of pre-service science teachers considering my thoughts.

2.2 Study Group

This study employs criterion sampling (Merriam, 2009). I have adopted as a criterion that pre-service science teachers have experienced the development process of scientific knowledge in the "The nature and teaching of science" course. I have included nine pre-service science teachers with high, medium, and low achievements based on their GPA. There was one male participant at each level. The study includes six females and three males as participants. While I coded the male participant with high academic achievement as HM, I coded the other two female participants at this level as HF1 and HF2. Similarly, while I coded the male participant with medium academic achievement as MM, I coded the other two female participants at this level as MF1 and MF2. Finally, while I coded the male participant with low academic achievement as LM, I coded the other two female participants at this level as LF1 and LF2.

2.3 Data Collection Tools

This study uses a document consisting of open-ended questions and focus-group interviews as data collection tools. I did a literature review to form the questions in the document (Adal, & Cakiroglu, 2022; Colburn, & Henriques, 2006; Dickerson et al., 2008; Lederman et al., 2002). I asked what students had learned about the nature of science in the first question. I asked how they could use the knowledge they learned when they became teachers in the future in the second question. Two experts in science education reviewed the document. They stated that it would be more appropriate to examine the educational philosophy adopted by the pre-service science teachers in the first question. From this point of view, I arranged the first question in line with the opinions of the experts. The questions in the document are as follows:

1- Please evaluate the educational philosophy you adopted based on the information you learned in the lesson.

2- Do you plan to use the educational philosophy you adopted when you become a teacher in the future? Why?

I conducted the focus group interview at the end of the lesson. I asked the participants again two questions I asked in the document. Since the second question in the document is detailed and not answered by everyone, I felt the need to ask this question again.

2.4 Data Collection Process

This study includes the participants voluntarily. The course has performed in the spring semester of 2021-2022. The course lasted 12 weeks, two hours per week. The course activities take into account the nature of science dimensions of Lederman (1992). In addition, the activities aim to explain the importance of constructivist philosophy instead of positivist philosophy in the learning process. The participants answered the questions at the end of each lesson.

2.5 Data Analysis

The study uses content analysis in the analysis process (Bogdan & Biklen, 1998). The answers of the participants were analyzed by considering the dimensions of the nature of science. Philosophy of education is the theme that will answer the research questions. Categories are the dimensions of the nature of science expressed by Lederman (1992). The codes were obtained from the statements of the participants. This study adopts deductive content analysis as it uses the existing categories in the literature. A science education specialist examined the themes, categories, and codes. Table 1 presents the theme, category, and codes.

Table 1. The theme, categories, and codes

Theme: Philosophy of Education				
Category	Codes			
	The philosophy adopted in the lesson		Future philosophy	
	Positivism	Constructivism	Positivism	Constructivism
Exchange and development of scientific knowledge	MF2, LF2, HF1	HM, HF2, MM, MF1, LM, LF1	HF1, MF2	HF2, MF1, LF1
The importance of logical inference	LF2	HM, HF1, HF2, MM, MF1, MF2, LM, LF1	HM	HF1, HF2, MM, MF2, LF1
The importance of experiment and observation	MF2, LM, LF2	HM, HF1, HF2, MM, MF1, LF1	LF2	HF1, HF2, MM, MF1
The role of the scientist in science	HM, MF2, LF2	HF1, HF2, MM, MF1, LM, LF1	MF2, LF2	HF1, HF2, MM, LM, LF1
The importance of imagination and creativity	MM	HM, HF1, HF2, MF1, MF2, LM, LF1, LF2	HM	HF2, MF1, MF2, LM, LF1, LF2, HF1
Influence of socio-cultural values on the development of scientific knowledge	MF2, LF2	HM, HF1, HF2, MM, MF1, LM, LF1	MF2	HM, HF1, HF2, MF1, LF1
Non-hierarchical order between theory and law	LM, LF2, MM, MF2, LF1	HM, HF1, HF2, MF1	LM, LF2, HF1	MF1, HF2

2.5 Validity and Reliability

I have taken into account the features suggested by Lincoln and Guba (1985) to ensure validity and reliability. I have mentioned these features in four steps: Credibility, transferability, dependability, and confirmability. To ensure credibility, the current study follows some steps. Firstly, the present study uses different data collection tools to produce more comprehensive results. Secondly, it presents the participants' experiences through direct quotation. Thirdly, this study provides an expert review for checking questions. To ensure transferability, I have chosen purposeful sampling. I have also tried to give detailed information about each stage of the study. To ensure dependability, I have presented the findings without comment. Also, I had the analysis checked by an expert after analyzing the data. To ensure confirmability, an expert in science education checked the findings and conclusions to recognize if they were consistent.

3. Results

The current study presents the findings under category headings. Findings specific to each category are presented through direct quotations.

3.1 Results in the Category of Exchange and Development of Scientific Knowledge

Table 2. Examples of the opinions of participants in the category of exchange and development of scientific knowledge

Codes			
The philosophy adopted in the lesson		Future philosophy	
Positivism	Constructivism	Positivism	Constructivism
MF2: *"Science has a dimension of changeability. This dimension states that scientific knowledge is changeable and developable"*.	HM: *"Scientific knowledge changes because scientific knowledge has the feature of being cumulative. Therefore, I need to understand when scientific knowledge was formed and influenced by what knowledge. I also wonder what scientists thought while they were producing scientific knowledge in those years"*.	MF2: *"I understood how to narrate to students that scientific knowledge is changeable. I realized that I could teach this dimension to students"*.	HF2: "*To understand the changeable nature of science, I will have my students do the experiments and activities we carried out in our lesson. I will help my students understand the changeable nature of science"*.

Table 2 presents one participant's opinion on each code. Similarly, below, I gave another participant's view on each code by quoting directly. Three participants (MF2, LF2, and HF1) held a positivist view about the changeable nature of scientific knowledge. For example, HF1 stated: *"I understand that scientific knowledge is not certain"*. On the other hand, other participants adopted the constructivist philosophy at the end of the course in this dimension. LF1 said: *"I realized that scientific knowledge can change and develop. Scientists who have studied this issue made me realize this situation"*.

Two participants stated that when they become teachers in the future, they will teach by adopting a positivist philosophy about the change and development of scientific knowledge. Three participants mentioned that they would adopt the constructivist philosophy in this dimension. For example, HF1 stated: *"I learned that I have to narrate to my students that scientific knowledge is not certain"*. On the other hand, LF1 said: *"I would make students realize that scientific knowledge is not certain and can change. I would make them realize that they can change scientific knowledge in the future"*.

3.2 Results in the Category of the importance of Logical Inference

Table 3. Examples of the opinions of participants in the category of the importance of logical inference

Codes			
The philosophy adopted in the lesson		Future philosophy	
Positivism	Constructivism	Positivism	Constructivism
LF2: *"Scientists arrive at different conclusions using the same data. Scientists need to make logical inferences"*.	MF1: *"Scientists like Lederman have argued that scientific knowledge can be developed by making logical inferences as a result of experiments and observations"*.	HM: *"By changing the variables, logical inference emerges as a result of long-term observation"*.	MM: "*I will encourage students to think through activities. I will guide them so they can inquire about a scientific event and expect solutions from them based on their observations"*.

Table 3 presents LF2's opinion on the positivist philosophy adopted in the lesson. On the other hand, eight participants held a constructivist view about the importance of logical inference. For example, LM expressed:

"Scientists have argued that scientific knowledge can be reached by making logical inferences as a result of observations".

Table 3 displays MM's opinion on the positivist philosophy. He will teach by adopting a positivist philosophy about the importance of logical inference. On the other hand, HF2 expressed the constructivist philosophy in this dimension. For example, HF2 stated: *"I will enable my students to do the activity in the future, and I will make them understand that scientific knowledge is based on logical inferences. I will also help them understand the working processes of scientists".*

3.3 Results in the Category of the Importance of Experiment and Observation

Table 4. Examples of the opinions of participants in the category of the importance of experiment and observation

Codes			
The philosophy adopted in the lesson		Future philosophy	
Positivism	Constructivism	Positivism	Constructivism
MF2: *"Experiments and observations are very important for the development of scientific knowledge".*	HF1: *"Scientists emphasized that experiments and observations are important for the exchange of scientific knowledge. Therefore, scientific knowledge is not absolute and may change with experiments and observations".*	LF2: *"I state that scientific knowledge is put forward through experiments and observations".*	MF1: "*When I become a teacher in the future, I will try to make my students find scientific information through experiments and observations".*

Table 4 shows MF2's positivist view on the importance of experimentation and observation that she adopted in the lesson. Similarly, LM said: *"Scientific knowledge is obtained through experiments and observations".* On the other hand, six participants believed in a constructivist view of this dimension. For example, MM mentioned: *"Scientists state that scientific knowledge can be reached through experiments and observations".*

Table 4 presents LF2's opinion on the positivist philosophy. She will teach by adopting a positivist philosophy about the importance of experiment and observation. On the other hand, four participants expressed the constructivist philosophy in this dimension. For example, HF2 stated: *"I enable my students to reach scientific knowledge through experiments and observations. I can develop my students' critical thinking skills through observations. I enable my students to reach the scientific knowledge themselves through experiments and observations".*

3.4 Results in the Category of the Role of the Scientist in Science

Table 5. Examples of the opinions of participants in the category of the role of the scientist in science

Codes			
The philosophy adopted in the lesson		Future philosophy	
Positivism	Constructivism	Positivism	Constructivism
LF2: *"The words of scientists should be included in the lectures. I think that scientists should continue trial and error while developing scientific knowledge".*	HF2: *"Scientists state that we need to understand the life, prior knowledge, and characteristics of the scientist to understand scientific knowledge".*	MF2: *"I tell my students those scientists have a different opinion".*	HF1: "*In my future lessons, I will make my students understand the lives of scientists so that they can learn meaningfully".*

Table 5 shows LF2's positivist view on the role of scientists that she adopted in the lesson. Similarly, HM said: *"Since scientists are affected by the environment they live in, they have had an impact on the emergence of scientific knowledge".* On the other hand, eight participants believed in a constructivist view of this dimension. For example, LM mentioned: *"Scientists like Lederman have stated that we can reach different conclusions about our studies because we all have different experiences. Therefore, the past experiences of scientists may play a role in reaching different results in scientific studies".*

Table 5 presents MF2's opinion on the positivist philosophy. She will teach her lesson by adopting a positivist philosophy about the role of scientists. Similarly, LF2 states: *"I explain that scientific knowledge emerges from the work of scientists"*. On the other hand, five participants expressed the constructivist philosophy in this dimension. For example, LF1 stated: *"In the future, I will make my students realize that women also make important contributions to scientific developments"*.

3.5 Results in the Category of the Importance of Imagination and Creativity

Table 6. Examples of the opinions of participants in the category of the importance of imagination and creativity

Codes			
The philosophy adopted in the lesson		Future philosophy	
Positivism	Constructivism	Positivism	Constructivism
MM: *"Imagination and creativity are used in the development and exchange of scientific knowledge"*.	HF2: *"Lederman emphasized the importance of imagination and creativity in the development process of scientific knowledge"*.	HM: *"I state that imagination is very effective in obtaining scientific knowledge"*.	MF1: "*To develop the imagination of my students, I will ask them the question of what would you do if it were you. To develop the imagination and creativity of my students, I will create an environment where they can freely express their ideas"*.

Table 6 shows MM's positivist view on the creativity and imagination that he adopted in the lesson. On the other hand, eight participants believed in a constructivist view of this dimension. For example, MF2 expressed: *"I will tell students to use their imagination and creativity in their learning process"*.

Table 6 presents HM's opinion on the positivist philosophy. He will teach his lesson by adopting a positivist philosophy about creativity and imagination. On the other hand, seven participants expressed the constructivist philosophy in this dimension. For example, LM stated: *"I will expect my students to discuss what they could do if they were scientists developing theories about gases"*.

3.6 Results in the Category of the Influence of Socio-Cultural Values on the Development of Scientific Knowledge

Table 7. Examples of the opinions of participants in the category of the influence of socio-cultural values on the development of scientific knowledge

Codes			
The philosophy adopted in the lesson		Future philosophy	
Positivism	Constructivism	Positivism	Constructivism
MF2: *"Scientific knowledge is affected by socio-cultural values"*.	MM: *"Scientists made me realize that religious beliefs and environmental factors are influential in the development of science"*.	MF2: *"To explain that scientific knowledge is influenced by socio-cultural values, I will explain the cultures of scientists to my students"*.	HF2: "*To show my students that language has a great impact on the development of science, I will make every effort to ensure that my students and I use scientific language correctly"*.

Table 7 shows MF2's positivist view on the socio-cultural values that she adopted in the lesson. Similarly, LF2 emphasized: "*Scientific knowledge is affected by socio-cultural values"*. On the other hand, seven participants believed in a constructivist view of this dimension. For example, LM explained: *"To create socio-cultural awareness in students, no explicit knowledge should be presented"*.

Table 7 presents MF2's opinion on the positivist philosophy. She will teach her lesson by adopting a positivist philosophy about socio-cultural values. On the other hand, five participants expressed the constructivist philosophy in this dimension. For example, LF1 stated: *"I will use scientific language effectively so that students do not have misconceptions"*.

3.7 Findings in the Category of the Non-Hierarchical Order between Theory and Law

Table 8. Examples of the opinions of participants in the category of the non-hierarchical order between theory and law

Codes			
The philosophy adopted in the lesson		Future philosophy	
Positivism	Constructivism	Positivism	Constructivism
LM: *"Theories explain phenomena that emerge as a result of unrelated observations in various fields of research. In addition, the theory is an indirect statement used to explain observable phenomena. Laws are mathematical relations. Laws are direct statements that describe observable phenomena in nature. There is a hierarchy between theory and law".*	HM: *"Scientists state that there is no hierarchy between law and theory. They also state that some laws were created before theories. Boyle, for example, expressed his law in 1670. In 1870, the kinetic molecular theory explaining this law was introduced to the scientific world".*	LM: *"I will read theory and laws to my students in the future".*	MF1: "*I will make my students realize that the law is not 100% certain".*

Table 8 indicates LM's positivist view on the socio-cultural values that she adopted in the lesson. LM had a misconception that He thought there was a hierarchical relationship between theory and law. Similarly, LF2 explained: "*I learned in this lesson that laws can change. I realized that there are theories that explain the laws. I also learned that there is no hierarchical relationship between theory and law"*. On the other hand, four participants believed in a constructivist view of this dimension. For example, MF1 explained: *"Based on the opinions of scientists, I will make my students comprehend the concepts of law and theory".*

Table 8 presents HM's opinion on the positivist philosophy. He will teach his lesson by adopting a positivist philosophy about the non-hierarchical order between theory and law. On the other hand, MF1 and HF2 expressed the constructivist philosophy in this dimension. For example, HF2 said: *"In the future, I will try to eliminate the misconception of the hierarchical relationship between theory and law in my students"*.

3.8 Findings Related to the Focus Group Interview

Table 9. Classification of the participants according to their philosophical opinions

Codes					
The philosophy adopted in the lesson			Future philosophy		
Participant	Positivism	Constructivism	Participant	Positivism	Constructivism
HF1	1	6	HF1	2	5
HF2	-	7	HF2	-	7
HM	1	6	**HM**	3	1
MF1	-	7	MF1	-	5
MF2	5	2	**MF2**	3	2
MM	2	5	MM	-	3
LF1	-	7	LF1	-	5
LF2	6	1	**LF2**	3	1
LM	2	5	LM	1	2

As seen in Table 9, most of the participants described themselves as constructivists in terms of the nature of science in the document. Similarly, they continued their views in the focus group interview. Only HM had a different opinion than the one he expressed in the document. He said he adopted a constructivist philosophy. He stated that he would necessarily be a positivist because of the multiple-choice exam system in Turkey. LF2 and MF2 continued their positivist ideas during the interview and stated that they would adopt teacher-centered teaching in the future.

4. Discussion

The study concludes that the participants adopted constructivism as a philosophy after the lesson. Constructivist philosophy expects learners not to focus on what scientific knowledge is. In addition, constructivism emphasizes students' focus on how scientific knowledge is formed (O'Connor, 2022). Focusing on the development process of scientific knowledge is very important for the development of the inquiry skills of the future students of the participants.

The present study concludes that only two participants adopted a positivist view of the nature of science. These participants think that scientific ideas about the nature of science are not formed by scientists. They focus on absolute truths. For example, they state that scientific knowledge is changeable. They do not state that we are expressing that this information is subject to change according to the opinions of the scientists. In other words, they focus on the product rather than the development process of scientific knowledge. These participants did not consider these dimensions to be the views of Lederman (1992). On the contrary, they accepted the information they learned about this dimension as absolute truth.

This study argues that pre-service science teachers should be educated as constructivists. In addition, when they become teachers in the future, they should educate their students by adopting the constructivist philosophy. The current study contributes to the literature in two ways. First, the current study states that pre-service science teachers should be educated according to the constructivist philosophy to adopt the constructivist philosophy during their education (Pande & Bharathi, 2020). Secondly, the present study claims that the education system should be organized according to constructivist philosophy for pre-service science teachers to be constructivists in terms of the nature of science in the future (Adal, & Cakiroglu, 2022).

Pre-service science teachers have difficulties in adopting the constructivist philosophy. One of the reasons for this is that pre-service science teachers cannot benefit from faculty members who have adopted the constructivist philosophy during their education at the faculty of education (Crawford, 2007; Dickerson et al., 2008; Uzuntiryaki et al., 2010). They also expressed this reason during the focus group interview. Another reason is the multiple-choice high school and university entrance exams in Turkey. As long as there is an examination system based on a positivist philosophy, it will be very difficult for teachers to adopt constructivist philosophy (Işık et al. 2010). Moreover, the participants frequently criticized this positivist assessment and evaluation system during the focus group interview. Pre-service science teachers evaluated this system as a system that prevented them from adopting the constructivist philosophy.

In conclusion, the current study highlights the importance of philosophy in science education. Science education will be incomplete without philosophy. Therefore, this study will contribute to the pre-service science teachers' forming a philosophy toward constructivist teaching practices.

4.1 Suggestions

The present study suggests some recommendations based on the findings and limitations of the study. This study gives awareness to the people who create the science education program. Pre-service science teachers stated that although they adopted the constructivist philosophy, they could be positivists due to the system in the future. Therefore, curriculum organizers should organize the system according to the constructivist philosophy. The participants stated that the transition from positivist philosophy to constructivist philosophy would be easy when teachers use scientific language. Therefore, training should be given to pre-service teachers and teachers that will enable them to acquire the constructivist language of science.

This study first uses documents to collect data. Then, it aims to examine the data in-depth with a focus group interview. However, this study did not yield enough data on some aspects of the nature of science. Hence, future studies should use individually structured interviews to obtain in-depth data.

Conflict of Interest Statement

I do not have any personal or financial conflicts of interest with other people and institutions related to the research.

Ethical Statement and Informed Consent

In this study, all the rules specified to be followed within the scope of the "Higher Education Institutions Scientific Research and Publication Ethics Directive" were followed. None of the actions specified under the heading "Actions Contrary to Scientific Research and Publication Ethics", which is the second part of the directive, were taken. For data collection tools, permissions were obtained from Erciyes University. The identity information of the pre-service science teachers participating in the research was kept confidential.

References

Abd-El-Khalick, F., & Lederman, N. G. (2000). Improving science teachers' conceptions of nature of science: A critical review of the literature. *International Journal of Science Education, 22*(7), 665-701.

https://doi.org/10.1080/09500690050044044

Adal, E. E., & Cakiroglu, J. (2022). Investigation of pre-service science teachers' nature of science understanding and decision making on the socio-scientific issue through the Fractal Model. *Science & Education*, 1-37. https://doi.org/10.1007/s11191-022-00319-1

Ardac, D., & Akaygun, S. (2004). Effectiveness of multimedia-based instruction that emphasizes molecular representations on students' understanding of chemical change. *Journal of Research in Science Teaching, 41*(4), 317-337. https://doi.org/10.1002/tea.20005

Bogdan, R. C., & Biklen, S. N. (1998). *Qualitative research for education: an introduction to theory and methods.* Allyn and Bacon.

Colburn, A., & Henriques, L. (2006). Clergy views on evolution, creationism, science, and religion. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching, 43*(4), 419-442. https://doi.org/10.1002/tea.20109

Comte, A. (2015). *A general view of positivism*. Routledge. https://doi.org/10.4324/9781315645780

Crawford, B. A. (2007). Learning to teach science as inquiry in the rough and tumble of practice. *Journal of Research in Science Teaching, 44*, 613-642. https://doi.org/10.1002/tea.20157

Dickerson, D. L., Dawkins, K. R., & Penick, J. E. (2008). Clergy's views of the relationship between science and religious faith and the implications for science education. *Science & Education, 17*(4), 359-386. https://doi.org/10.1007/s11191-007-9099-1

Fosnot, C. T. (2013). *Constructivism: Theory, perspectives, and practice*. Teachers College Press.

Haladyna, T. M. (2004). *Developing and validating multiple-choice test items*. Routledge. https://doi.org/10.4324/9780203825945

Işık, A., Çiltaş, A., & Baş, F. (2010). Teacher training and the teaching profession. *Atatürk University Journal of Graduate School of Social Sciences, 14*(1), 53-62.

Knowlton, D. S. (2000). A theoretical framework for the online classroom: A defense and delineation of student-centered pedagogy. *New Directions for Teaching and Learning, 2000*(84), 5-14. https://doi.org/10.1002/tl.841

Kolakowski, L. (1993). An overall view of positivism. *Social Research: Philosophy, Politics, and Practice*, 1-8.

Laverty, S. M. (2003). Hermeneutic phenomenology and phenomenology: A comparison of historical and methodological considerations. *International Journal of Qualitative Methods, 2*(3), 21-35. https://doi.org/10.1177/160940690300200303

Lederman, N. G. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching, 29*(4), 331-359. https://doi.org/10.1002/tea.3660290404

Lederman, N. G., & Lederman, J. S. (2014). Research on teaching and learning of nature of science. In *Handbook of research on science education, volume II* (pp. 614-634). Routledge. https://doi.org/10.4324/9780203097267-41

Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of nature of science questionnaire: Toward valid and meaningful assessment of learners' conceptions of nature of science. *Journal of Research in Science Teaching, 39*(6), 497-521. https://doi.org/10.1002/tea.10034

Lederman, N., Wade, P., & Bell, R. L. (1998). Assessing understanding of the nature of science: A historical perspective. In *The nature of science in science education* (pp. 331-350). Springer, Dordrecht. https://doi.org/10.1007/0-306-47215-5_21

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Sage Publication. https://doi.org/10.1016/0147-1767(85)90062-8

Mayer, R. E. (2002). Rote versus meaningful learning. *Theory into Practice, 41*(4), 226-232. https://doi.org/10.1207/s15430421tip4104_4

Merriam, S. B. (2009). *Qualitative research* (2nd ed.). Jossey-Bass.

O'Connor, K. (2022). Constructivism, curriculum and the knowledge question: tensions and challenges for higher education. *Studies in Higher Education, 47*(2), 412-422. https://doi.org/10.1080/03075079.2020.1750585

Pande, M., & Bharathi, S. V. (2020). Theoretical foundations of design thinking–A constructivism learning approach to design thinking. *Thinking Skills and Creativity, 36*, 100637. https://doi.org/10.1016/j.tsc.2020.100637

Uzuntiryaki, E., Boz, Y., Kirbulut, D., & Bektas, O. (2010). Do pre-service chemistry teachers reflect their beliefs about constructivism in their teaching practices? *Research in science education, 40*(3), 403-424. https://doi.org/10.1007/s11165-009-9127-z

Van Manen, M. (2007). Phenomenology of practice. *Phenomenology & Practice, 1*(1), 11-30. https://doi.org/10.29173/pandpr19803