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Preservice Teachers' Experience of History and Philosophy of Science Course: A Phenomenological Research

Öğretmen Adaylarının Bilim Tarihi ve Felsefesi Dersi Deneyimleri: Bir Fenomenoloji Araştırması

Sevim BEZEN* Celal BAYRAK**

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ABSTRACT: This research aimed to lay bare pre-service teachers' experience of History and Philosophy of Science courses. Being a phenomenological design, this research has 19 pre-service teachers (age range 19-22 years; 10 male, 9 female) in its research group. Semi-structured interviews were used to collect data for the study. Seven open-ended questions prepared by the researchers regarding this research were directed at the pre-service teachers. This data was analysed by content analysis within the frame of descriptive phenomenology. At the end of this research, pre-service teacher experiences of History and Philosophy of Science were gathered under the following main themes: "In my opinion, the History and Philosophy of Science course…," "What kind of teaching I would do if it were me?" and "Have my Expectations Been Met?" It was determined that pre-service teachers support constructivist teaching, they use positive expressions concerning the course's educative and directive aspects, and they made some suggestions. One view that has come to the fore in the research was that a pre-service teacher should complete this course. It can be suggested that pre-service teachers should complete this course for their proficiency and personal growth.

Keywords: A history of science, phenomenological approach, philosophy of science, pre-service teachers, qualitative research.

ÖZ: Bu araştırmada, öğretmen adaylarının bilim tarihi ve felsefesi dersi deneyimlerinin ortaya çıkarılması amaçlanmıştır. Fenomenoloji deseninin benimsendiği araştırmanın çalışma grubunu 19 öğretmen adayı (yaş aralığı 19-22; 10 erkek, 9 kadın) oluşturmaktadır. Araştırmanın verileri, yarı-yapılandırılmış görüşme tekniği aracılığıyla toplanmıştır. Araştırmanın amacına yönelik araştırmacılar tarafından hazırlanmış olan yedi açık uçlu soru öğretmen adaylarına yöneltilmiştir. Araştırmada elde edilen veriler betimleyici fenomenoloji çerçevesinde içerik analiziyle çözümlenmiştir. Araştırma sonucunda öğretmen adaylarının bilim tarihi ve felsefesi deneyimleri "Bana Göre Bilim Tarihi ve Felsefesi Dersi…", "Ben Olsam Nasıl Bir Öğretim Gerçekleştirirdim?" ve "Beklentilerim Karşılandı mı?" ana temaları altında toplanmıştır. Adayların süreçte yapılandırmacı öğretimi destekledikleri, dersin öğretici ve yönlendirici yönüyle ilgili olumlu ifadeler kullandıkları ve çeşitli önerilerde bulundukları tespit edilmiştir. Araştırmada en çok öne çıkan görüş ise, eğitim fakültesinden mezun olacak her bir öğretmen adayı tarafından bilim tarihi ve felsefesi dersinin öğreniminin tamamlaması gerektiği olmuştur. Öğretmen adaylarının alan yetkinlikleri ve bireysel gelişimleri açısından ilgili dersin öğrenimini tamamlamaları gerektiği düşünülmektedir.

Anahtar kelimeler: Bilim tarihi, bilim felsefesi, fenomenoloji yaklaşımı, nitel araştırma, öğretmen adayları.

* *Corresponding Author*: Dr., Hacettepe University, Ankara, Turkey, sevimbezen@hacettepe.edu.tr, https://orcid.org/0000-0002-0304-5314
** Prof. Dr., Hacettepe University, Ankara, Turkey, cbayrak@hacettepe.edu.tr, https://orcid.org/0000-0002-9269-2029

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Science is defined as an activity that has been used by humankind to explain the universe. It is also regarded as a process that stems from human curiosity. In this process, humankind's place in the universe and its living conditions are explained. In short, science is a process in which knowledge is generated; and it is a significant aspect of our cultural and social life (Matthews, 1989). Human values, political and economic problems, and the aims of education can be discussed thanks to science (Harding, 2017). However, to do so, there is a need for people who can appreciate the place of science within the intellectual and social scheme and who have a highly developed understanding of science. The importance of teaching History and Philosophy of Science while raising a generation that has a critical approach to scientific knowledge and discussion has already been emphasised (Petersen et al., 2020). Indeed, related to several branches of science such as history and philosophy, History and Philosophy of Science is defined as the story of the birth and development of science (Kampourakis, 2019). In other words, the teaching process of History and Philosophy of Science involves science's contribution to society and scientists' efforts (Gandolfi, 2018). In this process, it was argued, students realise how science is indeed part of human development (Chapel, 2004).

History and Philosophy of Science have found their place in education programmes' priorities because concepts in education programmes can be taught in an integrated manner through History and Philosophy of Science (Irzik & Nola, 2014). For instance, learning History and Philosophy of Science is effective in developing problem-solving, decision-making skills, and scientific knowledge perception of pre-service teachers enrolled at faculties of education (Grüne-Yanoff, 2014). It is because science as a concept becomes concrete through the teaching of this course to make sense of scientific concepts (Matthews, 1989). Similarly, this course gives pre-service teachers the chance to interpret scientific knowledge's social and cultural effects. It also provides them with an environment where they can make sense of concepts, improve their individual ability to think, learn interdisciplinary knowledge, and make interdisciplinary connections by learning about scientists' lives and the historical period they lived (Williams & Rudge, 2016). In short, it is believed that solutions for problems in various areas of life can be found "with History and Philosophy of Science courses," and students or pre-service teachers can obtain several skills for social and cultural events (Matthews, 1989). Likewise, a teacher who has studied the History and Philosophy of Science can easily ensure conceptual change (Wandersee, 1986). In other words, teachers who have a command of historical developments can foresee possible difficulties to be faced (Çıbık, 2016; Lin et al., 2010). When taught about the historical context, students learn concepts by making sense of them, and a course enriched by History and Philosophy of Science improves their attitude towards the topic (Lin et al., 2010). In short, the literature shows how knowing the History and Philosophy of Science can enrich learning environments and increase students' reasoning and critical thinking (Clough, 2011). At this point, it is important to note that pre-service teachers' views of and attitudes towards History and Philosophy of Science courses are significant (Teixeira et al., 2012). Determining what their views and attitudes are would contribute to the field since these pre-service teachers are the ones who would transfer their knowledge of History and Philosophy of Science to the next generation (Kokkotas et al., 2009). Consequently, with all these expressions, the effect of the History and

Philosophy of Science courses was thus emphasised; most importantly, it is evident that this course should be integrated into the education programs (Gandolfi, 2020). In this respect, it is known that with the update in teacher training undergraduate programs in Turkey in 2018, History and Philosophy of Science courses are included in general knowledge elective courses. This course enabled pre-service teachers to have an opinion of disciplines different from their own such as mathematics, philosophy, literature, politics, and geography. Moreover, such a course is also aimed at making students appreciate the interconnectedness and the united nature of human success stories (Hodson, 2019; Matthews, 1989). For instance, in a study carried out by Güney and Bakanay (2018), it was determined that pre-service teachers' interests in their fields increased when they had the opportunity to establish a connection between the things they learned in History and Philosophy of Science courses and their fields. The study noted that pre-service teachers thought that communication was better, and the whole course ran much smoother when it was enriched by History and the Philosophy of Science. Moreover, pre-service teachers expressed that they lack the necessary knowledge of how to relate History and Philosophy of Science with their fields because they did not have a separate History and Philosophy of Science course. In this respect, it was revealed that teaching programs need a course that focuses solely on the History and Philosophy of Science and that this course should be compulsory for every pre-service teacher. Similarly, Yenikalaycı and Yüksel (2020) also consulted pre-service teachers' opinions on the History and Philosophy of Science. Their study asked pre-service teachers open-ended questions on Ancient Greece, Medieval Europe and Scholastic Thought, Islamic cultural geography, Mesopotamia, Renassaince Europe, and the Age of Enlightenment. At the end of the study, it was found out that pre-service teachers have incomplete or incorrect information even about the History and Philosophy of Science related to their fields because there was little room for the History and Philosophy of Science in teaching programs. In the study, it was voiced out that pre-service teachers need the teaching of a separate History and Philosophy of Science course to get rid of their incorrect or incomplete knowledge. In conclusion, based on the studies carried out in Turkey in recent years, it can be argued that History and Philosophy of Science courses are a necessity; they would provide a significant advantage for pre-service teachers in their professional lives, and therefore, the views of pre-service teachers who have this experience would give a new impulse to the field.

Aim

This research aims to lay bare pre-service teachers' experience of History and Philosophy of Science courses. To this end, the History and Philosophy of Science course, which has been offered as an elective for the first time, was selected; and the views of pre-service teachers from different disciplines were examined with a phenomenological outlook. The study sought an answer to the question: "How do pre-service teachers make sense of their experience of the History and Philosophy of Science course?"

Method

Research Design

This research was designed in the phenomenology design because it focused on how pre-service teachers make sense of their personal experience and the nature of making sense of things (Christensen et al., 2015; Patton, 2014). Phenomenology design provides rich ideas about how pre-service teachers make sense of their experience (Smith & Osborn, 2015). Moustakas (1994) also argues that the contexts and situations affecting the phenomena can be determined, and expertise can easily be put forth (Creswell, 2013). In this respect, this study aimed to determine how pre-service teachers make sense of and experience the History and Philosophy of Science course and determine their views of this course. Therefore, it was decided that descriptive phenomenology would explain this situation because it aimed to describe pre-service teachers' perceptions, ideas, and experiences while revealing their knowledge. Individuals' experiences could be approached using descriptive phenomenology (Weinberg et al., 2018).

In the study, the experiences of the pre-service teacher were evaluated through descriptive phenomenology irrespective of the subjective convictions of the researchers. The meaning of their experiences and how their experiences were interpreted by themselves were investigated without reducing them to a biological entity (Vagle, 2018, p. 28). This study aimed to make visible the invisible aspects of pre-service teachers' experiences; it did not aim to put forward or confirm any theory while doing this. The investigation process progressed by employing an unbiased and critical perspective. As such, lived experiences could be described (Dahlberg et al., 2008). In short, the study used the descriptive phenomenology research design planned by Giorgi (2009, p. 166) by turning Edmund Husserl's transcendental phenomenology into a research method.

Study Group

The researchers applied at the Ethics Committee of a Turkish state university where the research was planned to be realised. After receiving a positive response from the said committee, the researchers contacted the pre-service teachers enrolled in the History and Philosophy of Science course at this university's education faculty. Study group of this research was determined by the voluntary participation of pre-service teachers who enrolled in the History and Philosophy of Science course during the Fall semester of the 2020-2021 academic year. The 19 pre-service teachers (age range 19-22; 10 Male, 9 Female) were sophomores at the education faculty. Five of these pre-service teachers' study Guidance and Psychological Counselling, four of them study Science Education, three of them study Computer and Instructional Technology Education, two of the study Primary School Mathematics Education, two of them study Biology Education, one of them study Chemistry Education, one of them study Physics Education and one of them study Mathematics Education. There are various views on the number of people in a study group in phenomenology research in literature. Based on Dukes and Polkinghorne, Creswell (2014) argues that the number of participants can vary between 3 and 25 while Dukes (1984) suggests 3-10 people and Polkinghorne (1989) offers 5-25 people as participants. In this respect, this study considered the literature and the voluntary participation of 19 pre-service teachers. These pre-service

teachers elected the History and Philosophy of Science course and experienced the History and Philosophy of Science in their natural learning processes.

History and Philosophy of Science Course

In this study, the teaching was carried out by being faithful to the History and Philosophy of Science course, which is part of the teacher training undergraduate program and aims to teach concepts holistically with the History and Philosophy of Science. Therefore, during the course period, science was mentioned in the old age, the middle age, the new era, the modern era, the Hellenistic era, the renaissance, Islam, the novel, and ancient Greece. The History and Philosophy of Science course were taught each subject for a semester according to the following four steps (Şeker et al., 2013):

Interest step: In this step, pre-service teachers were attracted to the course with biographical stories about scientists. For instance, Blaise Pascal (1623-1662) was made into account as follows: "Pascal's genius manifested when he was rather young. When he was 12, he started drawing circles and equilateral triangles. Although he did not know the geometry, he discovered that the sum of the triangle's interior angles equals two right angles. As a child, he asked his father, "What does geometry study?" His father replied, "It studies drawing shapes correctly and examines the relationship between parts of those shapes." Based on this answer, Pascal secretly formulated geometry theories and started to prove them. Finally, his father noticed his son's talent, and he gave him Euclid's elements and Apollonius' conics.

Socio-cultural Step: In the socio-cultural step, the aim was to correlate science and society's history and philosophy. Social repercussions of the scientists' work were examined in terms of science, culture, and technology. For instance, of course, the printing machine invented by Johannes Gutenberg in 1436 was relatively primitive at the beginning. However, it was still highly significant as a tool in initiating mass printing. Then, this invention was discussed in the course in terms of science, society, and technology.

Epistemological Step: At this step, methods scientists use in generating scientific knowledge were introduced to pre-service teachers, and the objective was for students to understand the changeability of science. During this introduction, the lecturer was present in the classroom as a guide. At this point, for instance, a video about Galileo Galilei (1564-1642) was shown to students (Link: https://www.youtube.com/watch?v=LPG8XNFLRsk). Science tells that a previously moving object would stop if it is left on its device; its movement can be maintained only by a push or pull from an external force. The video shows that Galileo subscribes to a contrary view and contends that "A moving object would maintain its movement at a monotonous speed when it is freed from external factors." Galileo tried to prove this to his audience, especially to the professors whose courses he was enrolled in, by throwing lead pieces of different weight from the Pisa Tower. In this respect, the process in which Galileo exhibited the changeability of science and discovered two significant laws of physics was presented to the students via this video.

Conceptual Step: In this final step, by creating discussion opportunities, students were enabled to realise the similarities between the conceptual structures they formed during the learning process of this course and the concepts they have developed in their minds before concerning the History and Philosophy of Science. At the same time, pre-

service teachers supported structuring their field knowledge and discussing ideas through group studies.

Data Collection and Application

Data of this research were collected by semi-structured interview technique. In qualitative studies, interviews are called "purposeful chats," and here, the aim was to reveal the pre-service teacher experience (Merriam, 2009). First, seven open-ended questions prepared by the researchers regarding this research were directed at the pre-service teachers. The questions were finalized in line with expert opinions. To reach rich discourse, interactive interviews were carried out with the pre-service teachers; a thorough examination of pre-service teachers' experiences was aimed by asking flexible in the questions and providing additional questions (Burns & Peacock, 2019). Interviews were realised one-on-one following the last week of the semester, with three weeks on the place, days, and hours determined by the pre-service teachers themselves; they took about 50-55 minutes. In this process, each pre-service teacher was met twice. All interviews were audio-recorded with the permission of pre-service teachers. Data were analysed after these audio recordings were transmitted to digital media.

In the interviews, the following questions were asked:

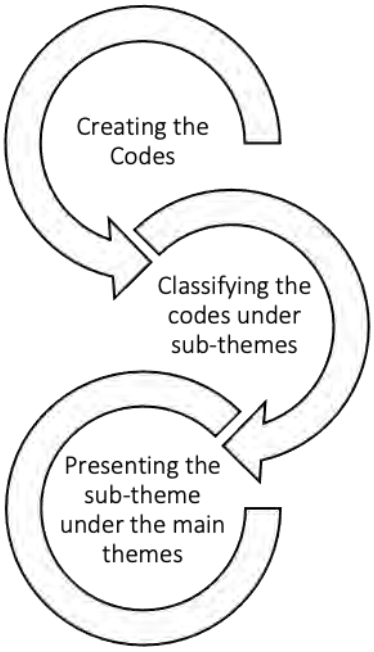
- Could you please explain what the History and Philosophy of Science courses mean for you?
- How would you, as a pre-service teacher, define the place of History and Philosophy of Science courses in education? Explain in detail.
- In your opinion, what is the appropriate way to teach the History and Philosophy of Science course? Explain in detail.
- Keeping in mind your educational journey, what teaching level do you think is appropriate for the History and Philosophy of Science course? Explain in detail.
- Has taken the History and Philosophy of Science course made you notice that you have erroneous thoughts that you thought were true? Explain in detail.
- Have your expectations concerning the History and Philosophy of Science courses been met in the process? Explain.
- What quality can a lecturer teaching History and Philosophy of Science have for teaching to be effective? Explain.

Data Analysis

Qualitative data obtained in this research were analysed by content analysis within the framework of descriptive phenomenology. Analysis steps utilised in the study can be found in Figure 1.

Figure 1

Data Analysis Steps



As shown in Figure 1, interviews conducted with the pre-service teachers were transcribed; these transcriptions were read and re-read. Then, expressions of a similar nature were brought together to create codes. For instance, "*I think the past should be recreated in the course environment by sample case texts. I think simulations and demonstration experiments can be employed to do so (PT#5)",* along with similar expressions by pre-service teachers showed that case studies, demonstration experiments, video shows, experiments, simulations, questions and answers, discussions, and group studies techniques should be utilised in the teaching of the History and Philosophy of Science courses. When these views gathered similar expressions, codes such as case studies, demonstration experiments, video shows, experiments, simulations, questions and answers, discussions, and group studies were formed. Then, these codes were classified under sub-themes in a meaningful way, taking into account the characteristics of these codes. Because the codes given in the sample support constructivist teaching, it was decided that the codes should be gathered under the 'Constructivist Teaching' sub-theme. Finally, sub-themes were presented under the main themes to indicate what each section meant to be easily understandable by the reader. To this end, the constructivist teaching sub-theme was presented under the main theme titled "What Kind of a Teaching Would I do If It Were Me?" Formed as such by the researchers, the codes, sub-themes, and main themes were constantly revised during the process. The codes, sub-themes, and the main themes determined by the researchers were presented to experts who are specialised in content analysis for qualitative studies; two experts who hold PhDs in the field were asked to code the data. Thus, looking at the harmony and consistency between the researchers and the field experts, final themes, sub-themes and codes were decided; and a consensus about the schematic demonstration given in the findings section was also reached. As a result of data analysis, content analysis, three themes and several subthemes under these themes were reached. To support the research findings, pre-service teachers' views were

presented in the relevant section directly in the form of quotations. In the presence of direct quotes, personal information about the participants was not used for ethical reasons; instead, each pre-service teacher was given a code (PT1, PT2, …., PT19) (Creswell, 2013; Yin, 2014).

Validity and Reliability Studies

In the study, believability, transferability, consistency, and confirmability dimensions were handled within the context of validity and reliability. In this respect, a literature survey was carried out to ensure believability, and a conceptual framework was formed. Detailed information about the participants and all stages of the study were presented, expert opinion was consulted, thereby helping readers decide on the believability of the expressions. Pre-service teachers were informed about the aim of the study; confidentiality was emphasised so that pre-service teachers would feel safer and more comfortable during the interviews. Moreover, reliable data were obtained by having a prolonged interaction with the pre-service teachers. To ensure the transferability of the study, interviews and the analysis steps were explained in detail. Likewise, the study group, data collection tool, the process, and the data analysis were defined to make sense for the reader. Data obtained in the study were presented objectively by providing direct quotations; the relationship between the processes was also explained.

Moreover, the study was raised easily to comprehend by supporting it with figures and using accessible language (Creswell, 2014). For consistency, the data of the research and the conclusion should be consistent. To this end, interviews were recorded while they were being carried out face to face. Then the data set were coded first by multiple researchers and then by experts; accord between them was checked. When codings differed, a consensus was reached going over it together. In other words, inconsistencies in codes, sub-themes, and the main theme so that there is unity in data. Finally, within the scope of confirmability, data of the study, free of personal assumptions and biases, were confirmed by the conclusions reached by the survey. Relevant associations were drawn with the literature, and the findings were presented to the reader. Moreover, data analysed by the researchers were stored digitally to access whenever necessary (Creswell & Poth, 2018).

The Researchers' Role

In this research, the aim was to describe pre-service teachers' experience, and it was conducted by researchers with the knowledge of qualitative research in a curious process. In this process, researchers were open-minded, flexible, accommodating, patient, and emphatic; they were also determined, insistent, and curious. They conducted this research with the objectivity expected from a researcher doing descriptive phenomenology. Researchers, both proficient in their field and good listeners, were consistent and treated the pre-service teachers warmly and candidly. They listened to their expressions carefully, always keeping their values in mind. Moreover, they provided an environment in which pre-service teachers could answer questions honestly and comfortably. In conclusion, the researchers displayed a sensible and sensitive attitude in managing the process (Smith & Osborn, 2015).

Ethical Procedures

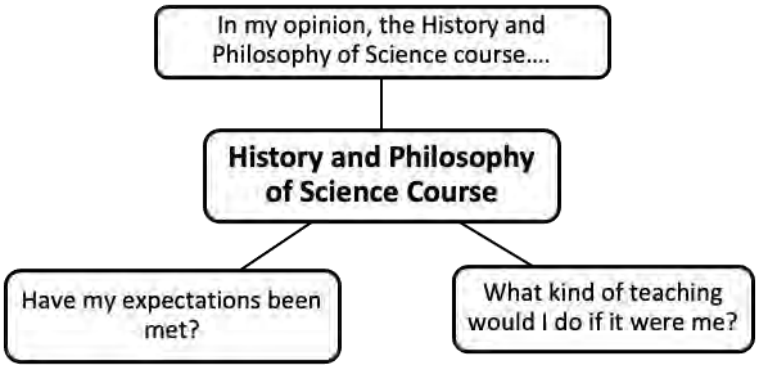
Pre-service teachers were briefed about the ethical issues and the voluntary nature of participation before the interviews started. They were informed that they could conclude the interview any time they liked. They do not have to answer any question; they do not want to answer so that their identity or any information related to their identity will never be revealed. The data obtained from the interviews will be kept confidential. This research was found ethically appropriate with the decision numbered 35853172-600 at the meeting held by Hacettepe University's Ethics Commission on 10 November 2020.

Findings

Findings obtained from the interviews were determined by the teaching process of the History and Philosophy of Science courses they have experienced. Pre-service teachers' perception of the study was gathered under three main themes. These themes are "In My Opinion, The History and Philosophy of Science Course…," "What Kind of a Teaching Would I Do If It Were Me?" and "Have My Expectations Been Met?" (Figure 2).

Figure 2

Preservice Teachers' Experience of History and Philosophy of Science Courses



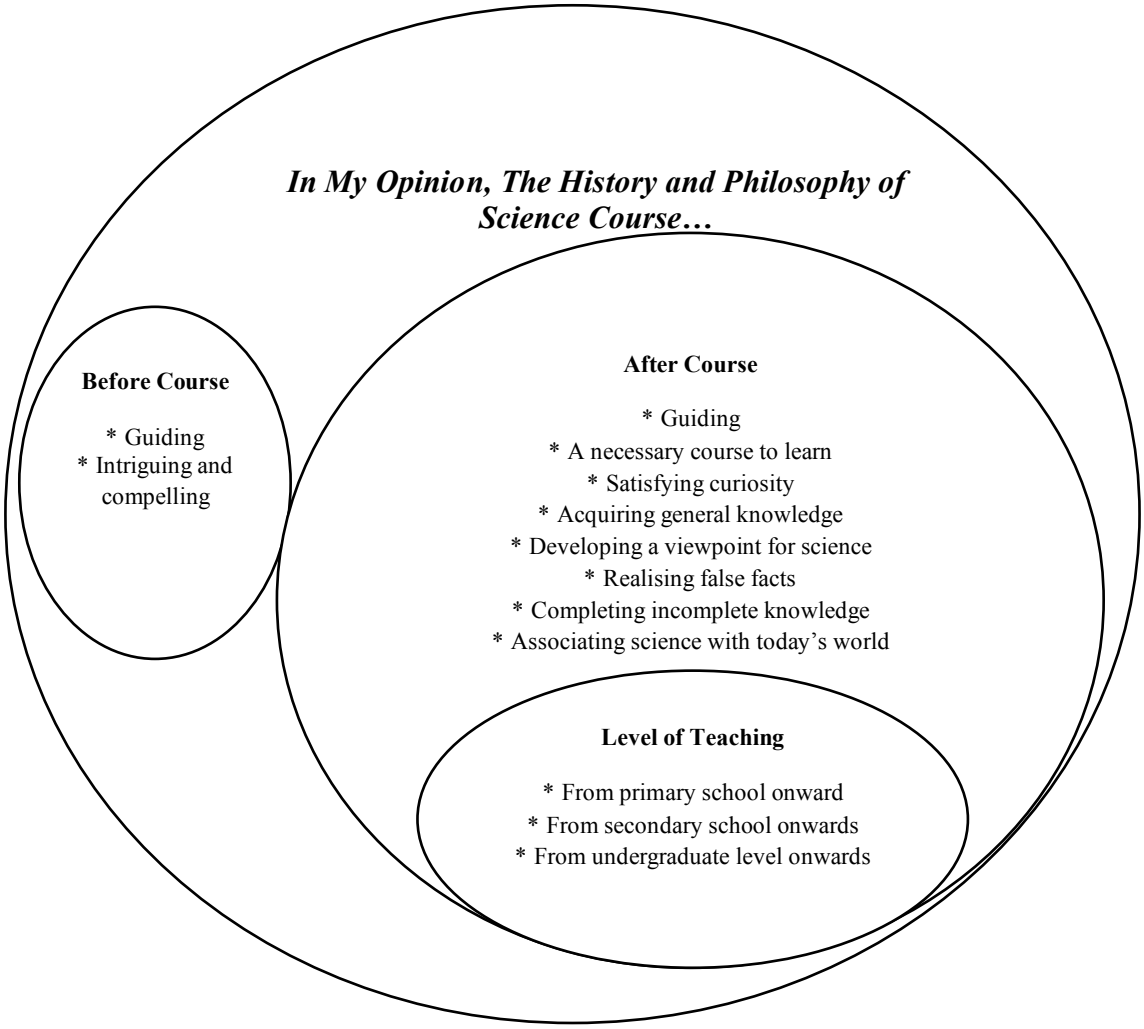
The themes determined in the research put forth how pre-service teachers make sense of the History and Philosophy of the Science courses, how they think the study should be taught, and what their expectations are. The content of these themes is given in detail below.

In My Opinion, The History and Philosophy of Science Course…: Before and After the Course

In this theme, pre-service teachers underlined what the History and Philosophy of the Science courses mean for them. "In My Opinion, The History and Philosophy of Science Course…" central theme was handled under two dimensions in this research. These were "before course" and "after course." Codes for these subthemes were also determined. Sub-themes and regulations concerning the central theme "In my opinion, the History and Philosophy of Science course…" can be found in detail in Figure 3.

Figure 3

Subthemes and Codes Concerning the Central Theme "In My Opinion, The History and Philosophy of Science Course…"



Before course, pre-service teachers indicated that the History and Philosophy of Science course would guide and were curious about the course. Examples of pre-service teachers' views on them before course subtheme can be found below: (PT: Preservice Teacher, #: Number):

> "History and Philosophy of Science courses remind me how and in what conditions science has progressed. I took this elective course, thinking that it would guide me because I have wanted to know more about the relationship between History and the Philosophy of Science and today's world (PT#4)."
>
> "… I have always wanted to learn about the History and Philosophy of Science, experience, inventions, and make sense of all of these. I have always been intrigued by how scientists developed their ideas or how events were grounded in science's philosophy (PT#19)."

Pre-service teachers' views revealed that they are willing to learn in this course and curious about its content. They maintained that they acquired some general knowledge thanks to this course and could relate scientific advancements in today's world.

After course, pre-service teachers still contended that this course was instructive; they also mentioned that their curiosity was satisfied. They maintained that this course contributed to their general knowledge and improved their perception of science. They

also indicated that they could complete their incomplete knowledge and realised they had specific false facts. It was determined that pre-service teachers had different views on when this course should be taught: their opinions varied from primary school to an undergraduate degree. Their ideas are presented below:

> "A teacher should have general knowledge, answer students' questions, and be proficient in their field; so, I can say that a pre-service teacher should take this course. I do believe this course satisfies one's sense of curiosity (PT#14)."
>
> "Everything in life stems from philosophy. In this course's teaching, we should first determine our philosophy of education and then after forming models, teach about scientists by mixing our teaching with history. For instance, we cannot teach a student about the theory of evolution before we teach them about science history. The student will not understand it if they cannot differentiate between a thesis and a hypothesis. In other words, this course should be taught based on science. This course may raise a generation who can relate scientific history to today and generate new ideas (PT#1)."
>
> "Thanks to this course, one can learn how scientists think and how science is done. This course can change our science view by showing us how some of our knowledge is based on false facts. I realised how much incomplete understanding I had in this course. I thought many of the inventions occurred in the West but learned that some of them indeed happened in the East (PT#8)."
>
> "This is an essential course taught to students progressively from the primary school social studies course. This course applies to all fields of life. In the primary school level, information may be limited to the first age so that topics become more attractive, and students are intrigued. More in-depth teaching can be done at the secondary school and undergraduate levels (PT#16)."
>
> "Students who have already decided on their field at the secondary school level can be briefed about this course's content, and they can be taught how they can obtain scientific knowledge in their areas. It can be ensured that students deepen their understanding without any mistrust of science and jointly analyse the birth philosophy and history of science (PT#11)."
>
> "Mentally mature students can focus on this course more efficiently and more willingly; that is why I think this course should be taught at the undergraduate level. This would enable more in-depth learning of topics and lecturers will more efficiently conduct the study with students who can quickly answer questions (PT#7)."

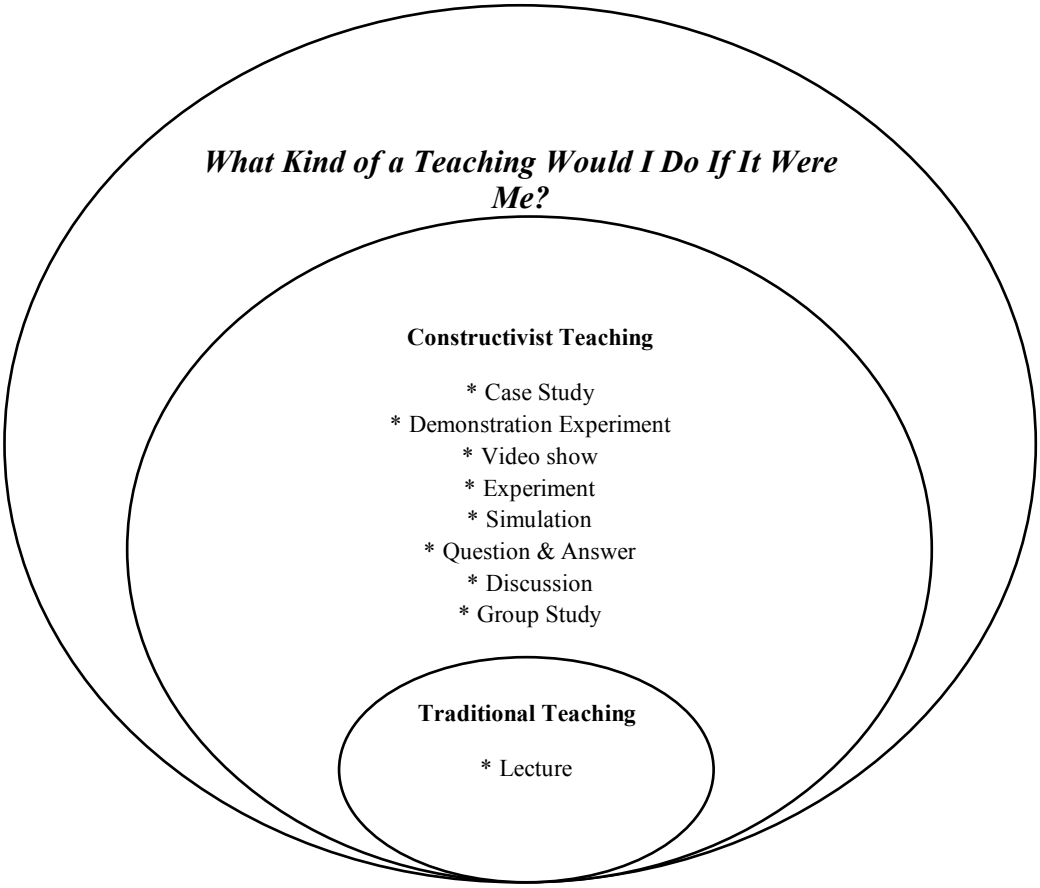
Pre-service teachers' expressions reveal that this course is essential; pre-service teachers think that each pre-service teacher should have sufficient knowledge of History and Philosophy of Science.

What Kind of a Teaching Would I Do If It Were Me?: Constructivist Teaching

Pre-service teachers regarded the teaching of History and Philosophy of Science courses in a single dimension. They argued that the teaching of this course should be done according to constructivist theory. Subthemes and codes concerning the central theme "What Kind of a Teaching Would I Do If It Were Me?" were given in detail in Figure 4.

Figure 4

Subthemes and Codes Concerning the Central Theme "What Kind of a Teaching Would I Do If It Were Me?"



Pre-service teachers emphasised that the teaching of History and Philosophy of Science should be done according to constructivist theory; they specified that such learning should be realised by using case studies, demonstration experiments, video shows, experiments, simulations, question and answers, discussions and group studies. Pre-service teachers also indicated that traditional teaching methods could also be utilised in certain parts of the course. Pre-service teachers' views are as follows:

> "In this course, students should be included in the process, and there should be frequent group studies. In my opinion, the level should not rely only on lecturing, but it can, of course, be done at specific points. Moreover, videos about scientists' inventions can be shown or experienced environment through experiments (PT#12)."
>
> "I think the past should be recreated in the course environment by sample case texts. I think simulations and demonstration experiments can be employed to do so (PT#5)."
>
> "Pre-service teachers enrolled in this elective course can be given a plan appropriate for their discipline. Scientists appealing to pre-service teachers can be examined and what they changed and what their viewpoint was can be focused on. Instead of a detailed lecture on these scientists' inventions, their contribution to science should be the focal point. Interesting questions can be used as an introduction, and then the course should continue with questions and answers. Examples from daily life can help create a discussion environment. As such, everything can be handled with a critical perspective (PT#17)."

Pre-service teachers' expressions indicate that they take constructivist theory to teach for the History and Philosophy of Science courses; they also support learning by doing and experiencing.

Have My Expectations Been Met?: Positive Expressions, Suggestions, and Characteristics of the Lecturer

It was determined that pre-service teachers explained their History and Philosophy of the Science course and their expectations of this course in a positive expression. Pre-service teachers also listed the necessary qualities required of the lecturer of this course. Pre-service teachers' names were presented under the central theme "Have My Expectations Been Met?" Subthemes were determined as "Positive Expressions", "Suggestions", and "Characteristics of the Lecturer." Subthemes and codes determined in the research were explained in detail in Figure 5.

The views of pre-service teachers presented under the "Positive Expressions" subtheme reveal that this course met their expectations because pre-service teachers underlined the educative aspect of this course; they also mentioned that learning occurred by doing and experiencing rather than by rote and that the use of different teaching methods and techniques ensured permanent education. Moreover, they said they learned while at the same time having fun. Pre-service teachers' views are as follows:

> "I was never bored in this course, and I think exciting points were adequately emphasised. I willingly came into the classroom and learned while having fun. Using different teaching methods and techniques made the subject even more comprehensible (PT#18)."

> "This is not a course in which you learn things by rote. Thus, I believe things should be known by doing, experiencing, and activities. I can say that this course was fun and useful for me because of its teaching process (PT#5)."

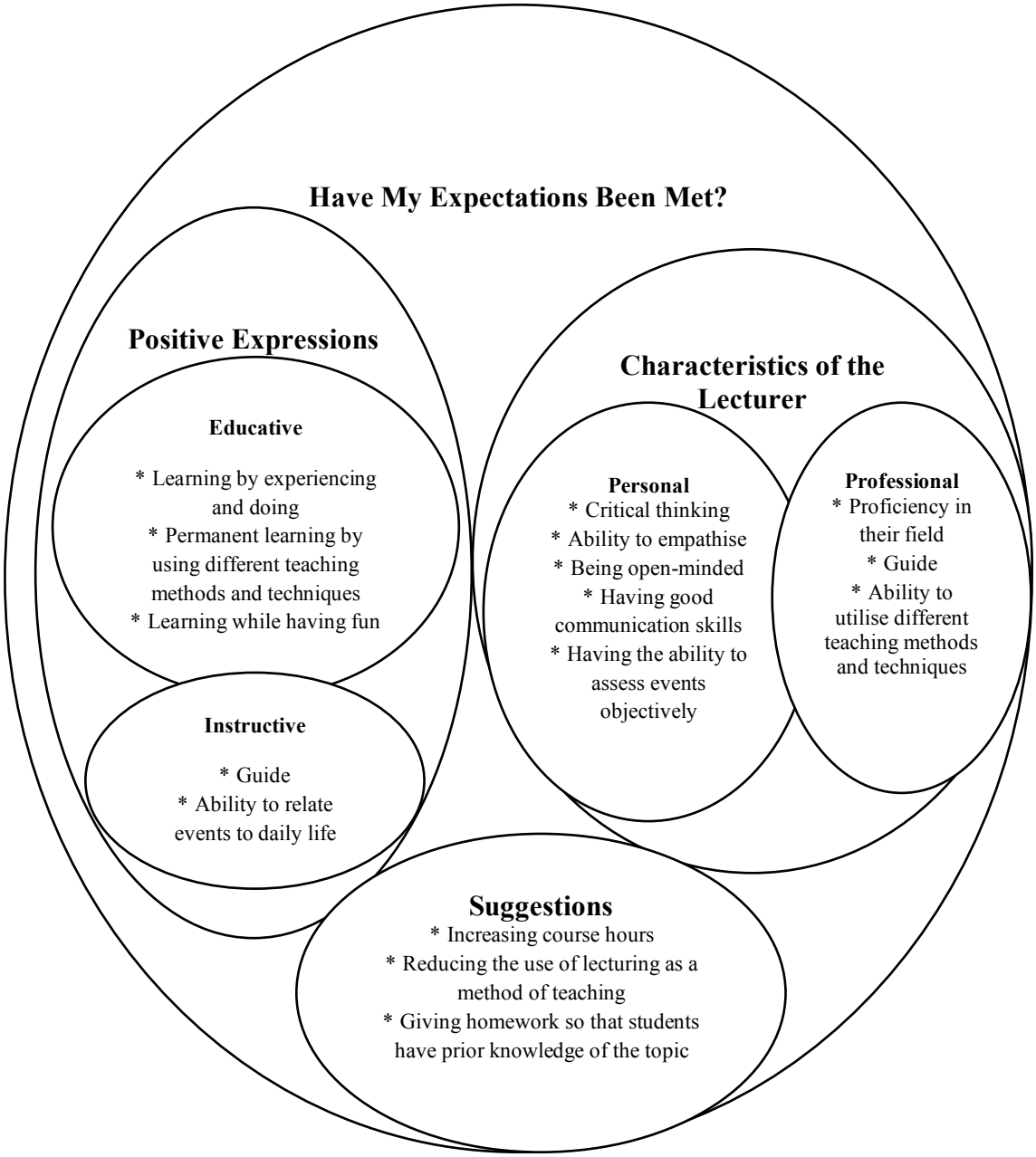
In the guiding dimension, pre-service teachers indicated that the lecturer adopted the role of a guide. Moreover, they underlined that the lecturer's guiding role created a healthy discussion environment, taking advantage of having pre-service teachers from different disciplines. Various activities enabled many of the pre-service teachers to have information outside of their field. About the instructive dimension, pre-service teachers also mentioned that they could relate things to daily life. Their views are as follows:

> "Under the lecturer's guidance, I had the opportunity to have in-course discussions with friends from other disciplines. I learned from my friends about things I have had no idea about before. I can say that a course consisting of students from different disciplines is an advantage (PT#7)."

> "I have always wanted to learn about the History and Philosophy of Science from A to Z, and I did thanks to this course. I noticed examples from daily life in particular; under our lecturer's guidance, I can now relate what I know of everyday life (PT#10)."

Figure 5

Subthemes and Codes Concerning the Central Theme "Have My Expectations Been Met?"



Under the "Suggestions" subtheme, pre-service teachers' suggestions for this course were presented. Pre-service teachers said that the course content was loaded, and the duration was short; they underlined that the course hours should be increased because two hours a week was not enough. As they mentioned before, they thought lecturing should be done only minimally in this course; they maintained that having prior knowledge of topics before coming to class would affect their learning. In other words, they believed that coming to the course prepared would help them make sense of the issues and enable them to be more active in the process. Some examples of pre-service teachers' views are as follows:

> "I think the course content is loaded and the duration limited; we had to rush through the topics, and thus we did not have enough time to internalise some concepts: they remained at the surface level and were not fully learned (PT#1)."

> "I think we should be given a type of homework before the course to come to the class prepared. I think this would help us make sense of the topics more efficiently, and we can participate in the process more actively. For example, we can watch an extract from a movie or read a book about the subject or study as a group before the course (PT#15)."

Pre-service teachers had constructive views, and they believed the course hours of this elective course should be increased.

Finally, pre-service teachers thought that the lecturer's characteristics were as useful to the teaching process as their professional qualities. In the professional dimension, pre-service teachers indicated that the lecturer should be proficient in their field, instructive, and should have the ability to use different teaching methods and techniques. The personal characteristics dimension said the lecturer should have critical thinking skills and empathise, be open-minded, communicative, and objective. Pre-service teachers' views are as follows:

> "The first thing is, the lecturer should be proficient in the field; only then can permanent learning be ensured. I also believe that the lecturer should utilise different teaching methods and techniques to be fun and educative. Hence, students became active participants in the study (PT#3)."

> "I think personal qualities are as important as professional proficiency to teach this course. I mean, a person who can think critically and can empathise, who is open-minded and objective, can conduct this course more effectively (PT#13)."

Pre-service teachers' views revealed that the lecturer's field did not make any difference; having specific professional and personal characteristics was considered more important.

Discussion, Conclusion, and Suggestions

This research aimed to lay by pre-service teachers' experience of History and Philosophy of Science courses. At the end of the study, pre-service teachers' knowledge was collected under several themes, namely, "In My Opinion, The History and Philosophy of Science Course…," "What Kind of a Teaching Would I Do If It Were Me?" and "Have My Expectations Been Met?" In the theme titled "In My Opinion, The History and Philosophy of Science Course …," pre-service teachers expressed their opinions before and after the course. In the article titled "What Kind of a Teaching Would I Do If It Were Me?" It was seen that pre-service teachers supported constructivist teaching. Finally, in the theme titled "Have My Expectations Been Met?" It was seen that pre-service teachers used positive expressions for the educative and instructive aspect of the course. They talked about the lecturer's characteristics, before course the History and Philosophy of Science course, the pre-service teachers listed among their reasons for electing this course. They thought this course was instructive and interested in taking this course. Since this was an elective course on general knowledge, it was evident that pre-service teachers willingly and curiously elected it. Indeed, it could be evinced that pre-service teachers wanted to understand the scientific process (Suprapto et al., 2019). After teaching, pre-service teachers' views were still complimentary, and they indicated that this course was instructive and that it was able to satisfy their curiosity. Niaz (2016) also mentioned that it resulted from the fact that pre-service teachers now knew the emergence of scientific knowledge and scientists' characteristics. It was thought that pre-service teachers objectively handled science, and having an increased interest in scientific studies might have been useful here (Fusti & Gilbert, 2000).

Additionally, pre-service teachers underlined how they acquired general knowledge and how their perception of science improved. This finding was compatible with the literature; raising pre-service teachers' awareness for this course was regarded as the cause of such development (Dougherty & Moore, 2019). Similarly, after this course, pre-service teachers completed their incomplete knowledge and realised the false facts that assumed to be true. As was also discussed in the literature, pre-service teachers associated the History and Philosophy of Science with the West (Song & Kim, 1999). Considering the level of education, the pre-service teachers' lack of prior knowledge of science in Islam, which is indeed part of their own culture, should be inquired. Pre-service teachers must know the importance of their own culture within the world culture and the history of civilisation; they are expected to have an increased interest in the History and Philosophy of Science, being inspired by scientists' contributions (Gandolfi, 2018).

It was revealed in this research that pre-service teachers' level of knowledge increased with the History and Philosophy of Science courses; pre-service teachers expressed how they had a cognitive change once they realised their mental contradictions. Çıbık's study (2016) supported this finding, which argued that pre-service teachers could associate science with daily life. In other words, pre-service teachers could now make connections between science and society, and they could find solutions to problems by using technological advancements (Gandolfi, 2020). The most frequently underlined expression in this research was that a pre-service teacher should take this course. Although this was an elective course, pre-service teachers could recommend taking it for personal development and professional proficiency. Indeed, after taking this course, pre-service teachers would be able to poke their own students' curiosity, enrich their in-course presentations, have lectures by creating contextual relations between concepts, and support their students in seeing the totality of a content (Fouad et al., 2015; Nouri et al., 2019). Pre-service teachers supported the use of constructivist teaching in the teaching of this course. It is believed that using constructivist teaching in this course would have an enormous effect on the cognitive development of pre-service teachers (Bächtold & Munier, 2019). Pre-service teachers themselves argued how utilising constructivist teaching would result in permanent learning; they maintained that different teaching methods and techniques should be employed to run the process. Other research also arrived at the same conclusion (Farris et al., 2019); research in the literature shows that pre-service teachers do not want to be taught in a monolithic manner; instead, they support learning that is realised by inquiry, encouraging creative ideas and through in-course interaction (Laçin-Şimşek, 2019). In this respect, pre-service teachers indicated that the lecturer should use different techniques such as case studies, demonstration experiments, simulations, group studies, question and answer sessions, and discussions. Besides pre-service teachers' expressions, there is evidence in the literature that constructivist teaching methods and techniques are useful in making sense of scientific knowledge (Norris et al., 2005). In the literature, it was also argued that constructivist teaching might increase the interest in the History and Philosophy of Science courses; a sense of curiosity may be poked by asking questions related to the subject, motivation can be improved, and students can become more active in the problem-solving process (Klassen, 2009).

In addition to these, pre-service teachers indicated that traditional teaching methods such as lecturing could be used in some parts of teaching along with constructivist teaching. However, pre-service teachers repeatedly emphasised how rote learning has no place in this course and showed that they do not support traditional instruction. Indeed, since this course requires conceptual and procedural knowledge, it can only be secured by innovative applications (Bächtold & Munier, 2019). Pre-service teachers also argued that the History and Philosophy of Science courses could be taught at various levels, beginning with primary school. It was indicated that the teaching of History and Philosophy of Science could be used beginning with social studies courses in primary schools; it could be done at the secondary school level in explaining how scientific knowledge is obtained and about the birth of science, and it could be used at the undergraduate level in in-depth learning. Several studies in the literature also contend that this course, which is believed to be appropriate for different teaching levels, should be provided for students in education programmes (Kim & Irving, 2010). In other words, the objective is to teach students how they can search for knowledge and have a theoretical basis. Another goal is ensuring that students learn the process of scientific research and the emergence of scientific knowledge. Moreover, arriving at conclusions about learning and reporting it and raising awareness about scientific research methods are among the desired outcomes (İngeç et al., 2016; Rudge & Howe, 2009).

Another result obtained from this research is that pre-service teachers learned by doing and experiencing things by having fun. The use of different teaching methods and techniques ensured permanent learning. Pre-service teachers mentioned the lecturer's instructive role; they maintained that they could now relate daily life things. Some conclusions were drawn in the literature about teaching History and Philosophy of Science based on constructivist theory (Bächtold & Munier, 2019; Garik et al., 2015; Hadzigeorgiou, 2006). Moreover, the research underlined that the lecturer created a lively discussion environment using the fact that there were students from different disciplines in the course, which ensured that the pre-service teachers could know outside of their areas via various activities. It shows that the lecturer's instructive role created an opportunity for pre-service teachers' academic success to increase; the lecturer helped for meaningful and permanent learning by giving students confidence and motivation (Nouri et al., 2019). It was determined in this research that pre-service teachers regarded the characteristics of a lecturer in two aspects. They indicated that the lecturer's unique features are as important as their professional proficiency. Professionally, the lecturer was expected to be proficient in their field, instructive, and use different teaching methods and techniques. Personally, the lecturer was expected to have skills in critical thinking, empathising, open-mindedness, communication, and being objective. Pre-service teachers' expressions revealed that this course's lecturer should have multiple qualities (Cross, 1916). Sarton (1930) also focused on the point and argued that the most critical factor in teaching History and Philosophy of Science is the lecturer because he believed that an inappropriately provided education would have devastating results. In this respect, this course should be taught by individuals capable of thoroughly explaining things.

Finally, pre-service teachers argued that the content of this course was packed while the duration was limited. It can be suggested at this point that the number of

course hours should be increased instead of omitting certain parts of the content (Emren et al., 2019). Another result of the research was that pre-service teachers believed that prior knowledge would be useful in their learning before coming to the course. Pre-service teachers' level of experience concerning History and Philosophy of Science is insufficient. Indeed, most of their prior knowledge comes from media or popular books (Ma & Wan, 2017; Metz et al., 2007). That is why pre-service teachers expressed that they could be given homework in the form of group work or based on an extract from a book or a movie before the course; it was determined that this was how they wanted to improve their prior knowledge levels. In other words, pre-service teachers believed that coming to the class prepared would ensure more permanent learning and more active course participation. These pre-service teachers' suggestions aim to increase education quality (Ma & Wan, 2017).

Limitations

Consequently, this research laid bare the pre-service teacher experience of History and Philosophy of Science courses. Participants of this research consisted of pre-service teachers who took the History and Philosophy of Science course for the first time in a state university. In this sense, the study reflects the views and experience of a limited group. Moreover, this research has a known limitation due to its research design, which does not allow its conclusions to be generalised. The difficulty of getting rich data, data analysis, determining a research group, and the researcher's experience also create limitations. To obtain rich data from pre-service teachers, interviews were held immediately following the course's teaching to minimise memory issues. The research aimed to keep in mind when determining the research group; pre-service teachers were selected only if they had experienced the History and Philosophy of Science course. In the data analysis, the whole data was examined about the formed themes, without losing sight of a holistic viewpoint. Finally, it can be argued that researchers have knowledge and experience in planning and running qualitative research (Creswell & Creswell, 2018). The research problem could be rehandled with more participants and through qualitative and mixed research approaches in prospective studies to overcome these limitations. The research problem can be discussed within the frame of different variables using various assessment tools and methods. Moreover, a comparative analysis of pre-service teachers' views and experiences and teachers who have taken this course would shed light on the field differently.

Implications

This study laid bare that teaching the History and Philosophy of Science is necessary for pre-service teachers' field proficiencies and personal growth. However, it also became evident that the teaching process of this course should be improved. In this regard, it is thought that in the faculties of education that teach the History and Philosophy of Science, it is necessary to develop teaching materials for the course, to simplify the rich content to be included in the curriculum in a planned manner, and to take into account the difficulty of appreciating the conditions of a time that may be so significantly different from today. For this, a dynamic interaction should be ensured between the lecturer, the curriculum, and the teaching materials to be used. The instructors are expected to carry out practical teaching, being aware of the difference

between the planned and the implemented course process, and using curriculum materials and additional/guide materials. It is thought that exciting and interactive activities that would support in-class interaction should be specially included in the teaching materials (Ma & Wan, 2017; Nouri et al., 2019). Moreover, it is believed that the inclusion of this course in the teacher training programs in Turkey since 2018 will increase the number of sources to be designed in this field, and these sources should be adapted to the teaching process.

Statement of Responsibility

Sevim Bezen; methodology, validation, formal analysis, investigation, resources, data curation, writing-original draft, writing – review & editing, visualization, supervision, project administration. Celal Bayrak; methodology, validation, writing-original draft, writing – review & editing, visualization, supervision, project administration.

Conflicts of Interest

The authors declare that they have no conflict of interest**.**

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