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Author Contribution Statement

[1] **Zeki APAYDIN** *Prof. Dr.* *Ondokuz Mayıs University,* *Samsun, Turkey*	Conceptualization, literature review, translation, and writing
[2] **Tuğçenur ÇAĞLIYAN REİS** *Lecturer* *Avrasya University* *Trabzon, Turkey*	Conceptualization, literature review, translation, and writing
[3] **Elif OMCA ÇOBANOĞLU** *Assoc. Prof. Dr.* *Ondokuz Mayıs University* *Samsun, Turkey*	Conceptualization, literature review, translation, and writing

Abstract

This study aims to determine the perceptions and levels of preservice science, preschool, and primary school teachers about epistemology, the nature of science, and scientific process skills. The phenomenological method, one of the qualitative research approaches was used. The study group consists of 24 selected preservice teachers based on the principle of voluntariness. The descriptive analysis method, one of the qualitative data analysis methods was used while analyzing the data, Analyzes were made by adapting the semi-structured interview form and coding applied by Smith and Wenk (2006) to Turkish. The findings are given together with the tables and supported by quotations from the participants. According to the results of the research, it was revealed that the preservice teachers were at a low level about the goal of science, the nature of science, the nature of the experimental process, the nature of hypotheses and theories, and the relationship between them, the change of hypotheses and theories, and scientific accuracy. It can be argued that the competence to comprehend the nature of science is very important, especially for preservice teachers who will take the responsibility of teaching science and natural sciences. Therefore, it can be concluded that higher education teacher training programs should be reorganized in the context of preservice teachers' gaining competence in epistemological beliefs and the concept of the nature of science.

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Research Article

A Phenomenological Study of Preservice Teachers' Epistemological Levels [*]

Zeki APAYDIN [1] **Tuğçenur ÇAĞLIYAN REİS** [2] **Elif Omca ÇOBANOĞLU** [3]

Abstract

This study aims to determine the perceptions and levels of preservice science, preschool, and primary school teachers about epistemology, the nature of science, and scientific process skills. The phenomenological method, one of the qualitative research approaches was used. The study group consists of 24 selected preservice teachers based on the principle of voluntariness. The descriptive analysis method, one of the qualitative data analysis methods was used while analyzing the data, Analyzes were made by adapting the semi-structured interview form and coding applied by Smith and Wenk (2006) to Turkish. The findings are given together with the tables and supported by quotations from the participants. According to the results of the research, it was revealed that the preservice teachers were at a low level about the goal of science, the nature of science, the nature of the experimental process, the nature of hypotheses and theories, and the relationship between them, the change of hypotheses and theories, and scientific accuracy. It can be argued that the competence to comprehend the nature of science is very important, especially for preservice teachers who will take the responsibility of teaching science and natural sciences. Therefore, it can be concluded that higher education teacher training programs should be reorganized in the context of preservice teachers' gaining competence in epistemological beliefs and the concept of the nature of science.

Keywords: Epistemological, phenomenological, nature of science, preservices teachers

1. INTRODUCTION

Learning the concepts of science at a meaningful level requires an awareness of the dimensions related to the nature of science and epistemology. International and national science teaching programs emphasize that it is not enough for students to learn only the content knowledge of science; process knowledge is especially vital in science teaching. In this context, many national and international studies have been conducted to determine science education students' perceptions and knowledge levels about epistemology, the nature of science, and scientific process skills (Aslangöz & Kırık, 2024; Smith & Wenk, 2006).

Epistemology examines the nature, source, verification and limits of knowledge (Hofer & Pintrich, 1997). It also investigates the structures and formation processes of scientific concepts and theories and how scientific knowledge is produced (Hofer, 2001). Epistemology underpins scientific inquiry and the resulting knowledge by providing an understanding of the conditions under which knowledge is considered valid and reliable. Students' epistemology plays an important role in the construction of knowledge (May & Etkina, 2002). Phenomenology aims to get to the essence of a

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[1] *Prof. Dr., Ondokuz Mayıs University, Faculty of Education, zapaydin@gmail.com , Samsun, Turkey*

[2] *Lecturer, Avrasya University, Vocational School of Health Services, tugcenrcglyn@gmail.com, Trabzon, Turkey*

[3] *Assoc. Prof. Dr., Ondokuz Mayıs University, Faculty of Education, omcacobanoglu@gmail.com, Samsun, Turkey*

Corresponding Author e-mail adress: tugcenrcglyn@gmail.com

phenomenon by focusing on the experiences of individuals and the meanings of these experiences. It is used to understand individuals' subjective perceptions and experiences about a particular subject (Creswell, 2017). In this context, when pre-service teachers' epistemological beliefs and their perceptions of the nature of science are examined with a phenomenological approach, it becomes possible to analyze their scientific thinking and understanding in depth.

It is possible to see that the literature on the nature of science in science education includes many studies (Ayvacı & Muradoğlu, 2021; Ozan Uluçınar & Sağır, 2020). Angın and Özenoğlu Kiremit (2017) aimed to reveal the views of preservice teachers studying in the departments of science, preschool, social studies education, and primary school education towards the nature of science. According to the findings of the study, it was revealed that preservice teachers did not express a realistic view of the nature of science and gave inadequate answers. Carey et al. (1989), conducted a study to reveal seventh-grade students' views on scientific knowledge and the nature of science. The findings of the study revealed that the students' initial epistemological beliefs were acquired passively and that their scientific knowledge was limited to nature, that is, they were limited to observation and description instead of explanation. This student view of the nature of science is consistent with the "copy theory", which can be interpreted as "ideas are exact replicas of natural phenomena", and students have a primary level of knowledge understanding, which is the lowest category. The studies that are conducted by Gürses et al. (2005), Khalick and Lederman (2000) are also similar literature studies on these subjects.

In the literature, it is seen that there are many studies including the perception levels of student groups with different cognitive levels towards the nature of science, theory of knowledge, and scientific process skills (Apaydın & Kandemir, 2018; Gobert & Pallant, 2004). In this context, our study is a qualitative-based comparison of pre-service science, pre-service preschool and classroom teachers, which enables the examination of pre-service teachers in different fields, and it is thought that its findings will provide new contributions to the field. The main reason for conducting this study with pre-service teachers is that they will assume an important responsibility in transferring scientific knowledge to their students and gaining scientific thinking skills in the future. A correct understanding of scientific thinking and the nature of knowledge is of great importance for teachers to be able to teach these concepts to their students effectively. In addition, determining pre-service teachers' perceptions of epistemology, nature of science and scientific process skills will provide important feedback for the development of their professional competencies.

This study aims to determine the perceptions and levels of preservice science, preschool, and primary school teachers about the theory of knowledge, the nature of science, and scientific process skills. For this general purpose, the following questions are sought to be answered:

1. What are the categorical knowledge levels of preservice science, preschool and primary school teachers?

a. What are the categorical knowledge levels about the goal of science?
b. What are the categorical knowledge levels about the nature of scientific questions?
c. What are the categorical knowledge levels about the nature of the experimental process?
d. What are the categorical knowledge levels about the nature of hypotheses and theories?
e.What are the categorical knowledge levels about the relationship between hypotheses and theories?
f. What are the categorical knowledge levels about the process of changing hypotheses and theories?
g. What are the categorical knowledge levels about scientific accuracy?

2. METHOD

The research is a study following the phenomenological design, which is one of the qualitative research methods. The phenomenological design can be considered as an in-depth study of individuals' cognitive structures, conceptualizations, or thoughts about a unique phenomenological situation. In this process, researchers try to obtain information about the participants' conceptualizations that they are not particularly aware of or not elaborated through interviews consisting of purpose-specific questions (Gürbüz & Şahin, 2017). In other words, in the phenomenological design, the focus is on the thought structures that individuals are aware of at the basic conceptual level and formally but are not relationally elaborated. In addition, due to the nature of qualitative research, the raw data obtained are not precise and generalizable. Rather, it is more interested in detailed explanations that reflect the current reality for the concepts related to the phenomenon that constitutes the subject of the research (Büyüköztürk et al., 2020). The analysis of qualitative raw data is descriptive. This study, which is suitable for the phenomenological design, aims to determine the perceptions and conceptualizations of preservice science, preschool, and classroom teachers towards epistemology, the nature of science, and scientific process skills.

2.1. Participants

The study group consisted of 23 preservice teachers studying in the departments of science education, preschool education, and classroom education at a university in the Black Sea Region of Turkey. Among the 23 preservice teachers, 7 of them are studying in science education, 7 in preschool education, and 8 in classroom education. One preservice teacher has a master's degree in science education. The preservice teachers in undergraduate education are at the third and fourth-grade level. The study group was determined through convenience sampling, one of the types of purposive sampling. Convenience sampling is related to the easy accessibility of the research group (Ekiz, 2013).

2.2. Data Collection Tools and Data Analysis

A semi-structured interview form inspired by Smith and Wenk's (2006) study was used as a data collection tool. To test the validity and reliability of the semi-structured interview form, the opinions of two field experts and two Turkish teachers were utilized for language appropriateness. Lastly, the semi-structured form was finalized as a result of the pilot application with two preservice teachers and in the light of the feedback received from the experts. The questions in the form were directed to the preservice teachers face-to-face in a semi-structured interview format. The opinions of the preservice teachers were recorded on voice recorders for approximately 20 minutes. The data obtained from the semi-structured interview form applied to the preservice teachers and from the voice recorder and video recorder were then transcribed.

In their study, Smith and Wenk (2006) examined the interview questions on the nature of science in three sections and five levels. It can be seen that the questions in the interview form are grouped under three different sections. In the first section, there are questions about the conceptual terms *theory*, *concept*, *and evidence* and the differences in the meaning of these terms. The first section includes questions aimed at revealing the goal of science, the nature of science, the nature of the experimental process, the nature of hypotheses and theories and the relationship between them, and the processes for changing hypotheses and theories. In the second part, there are questions to identify the participants' views on scientific accuracy; in the third part, two case studies are given on what might be the causes of scientific disagreements.

The coding for the goal of science in the first section are *''producing concrete things'', ''describing the situation'', ''discovering what it is''* at level 1, *''determining how the universe works; they cannot give examples of what they mean'', ''the question of how is important''* at level 1.5, *''it is the process by which ideas are tested through systematic observation and experimentation'', ''science* *is about understanding how phenomena in nature or in the physical universe work'', ''they can give one or more specific examples''* at level 2, *''it is about testing ideas about how the world, the physical universe, the mechanism of nature is (the how question)'', ''the openness of these ideas to testing at all times (the changeable nature of science)'', ''there is a theory-driven understanding of hypothesis''* at level 2.5, and *''the goal of science is about emerging theories with increasing explanatory power and explanatory scope'', ''hypothesis testing is implicit theory testing'', ''scientific knowledge is explicitly theory-driven''* at level 3.

The coding for the structure of scientific questions in the first section are *''asks questions about what it is''* at level 1, *''asks questions about how it works; they cannot give a specific example''*, *''scientists' questions are about how phenomena work'', ''questions are asked about how a directly observable variable affects another variable''* at level 1.5, *''asks how questions but these questions are not slogans without examples, i.e. participants can give original examples''*, *''scientists ask questions about how phenomena work and the reasons for their occurrence''* at level 2, *''it is about how phenomena work'', ''questions are testable in nature''* at level 2.5, and *''theory influences the tendency to ask how questions should be asked'', ''theories influence scientific questions'', ''students are aware of the intertwined nature of scientific questions'', ''questions are formulated in a way that can test a general scientific problem (secondary level questions)''* at level 3.

The coding of the nature of the experimental process in the first section are *''obtaining data or evidence about what is''*, *''obtaining data and evidence about phenomena or the external world''* at level 1, *''scientists find out how phenomena work''*, *''the experimental process is the measurement and comparison of variables that can be directly observed''* at level 1.5, *''the experimental process is hypothesis testing''*, *''it is the hypothesis that determines the experimental process''* at level 2, *''it is the testing of competing explanatory hypotheses''*, *''it consists of controlled designs''* at level 2.5, and *''it is not about direct testing of the hypothesis, but hypotheses and theories are tested indirectly through experiments''* at level 3.

The coding of the nature of hypotheses and theories in the first section are *''they may not know the meaning of the concepts (of hypothesis and theory)''*, *''at best they can say that they are the thoughts of scientists'''*, *''they do not know what the difference in meaning is for the concepts''* at level 1, *''hypotheses are predictions based on knowledge, there are no statements that these predictions will be tested through experiments''*, *''theories are considered as predictions or simple facts as well''* at level 1.5, *''they see the difference between hypothesis and theory as the degree to which it is proved or tested (theory is better tested/there is a hierarchical relationship in favor of theory/evidence is an important state or process)'', ''there is a possibility that students may say that the task of theory is different and the task of hypothesis is different''*, *''there seems to be an emphasis on quality and scope''* at level 2, *''hypotheses are ideas with explanatory power that are tested by experiments''*, *''theories are a system of well-tested hypotheses''* at level 2.5, *''theories are a conceptual system, a set of principles of causality to be used in explaining phenomena''*, *''theories are broad conceptual systems and have explanatory power for how the mechanism works/how the mechanism is''*, *''hypotheses are more specific ideas concerning a particular area of the physical universe''*, and *''hypotheses are more specific ideas concerning a particular area of the physical universe''*, *''new theories are broad and explanatory conceptual systems''* at level 3.

The coding of the relationship between hypotheses and theories in the first section are *''students cannot provide a consistent relationship statement about the difference''*, *''students can state that both are the same''* at level 1, *''hypotheses and theories are seen as different concepts''*, *''hypotheses are predictions''*, *''theories are considered as findings or facts''* at level 1.5, *''theories are better-tested hypotheses''*, *''hypothesis influences theory''* at level 2, '*'theory-driven hypothesis understanding has developed''*, *''theories are conceptual systems broader in scope than hypotheses''* at level 2.5, and *‘‘hypotheses are formulated in the light of theories’’*, *‘‘interpretation of data and the whole conceptual framework are influenced by theories’’* at level 3.

The coding of the process related to the change of hypotheses and theories in the first section are *‘‘change can occur when the experimental process does not go well, when mistakes are made, when you discover that you are wrong’’* at level 1, *‘‘the process of change is the process of hypothesis testing’’*, *‘‘they cannot distinguish between the process of change of hypothesis and theory in terms of easiness and difficulty’’*, *‘‘the change of hypothesis is easier than the change in theory’’*, *‘‘it says that the theory may be better tested’’* at level 1.5, *‘‘theories are better tested hypotheses’’*, *‘‘hypothesis influences theory’’* at level 2, *‘‘it is a meticulous process’’*, *‘‘testing of alternative hypotheses (ideas) that are proposed is also taken into account’’*, *‘‘both new ideas and new data are taken into account interactively’’*, *‘‘some ideas are difficult to change and others are changed in the light of evidences’’* at level 2.5, and *‘‘the change in theory is more difficult than the change in hypotheses’’*, *‘‘theories include new evidence and new ideas’’*, *‘‘the change in theory includes the development of new ideas or concepts as well as new data’’* at level 3.

The coding for the concept of scientific accuracy in the second section are *‘‘knowledge is certain’’* at level 1, *‘‘knowledge is certain in some areas, but not in other areas’’*, *‘‘in uncertainty, beliefs or majority opinion are more acceptable’’* at level 1.5, *‘‘theories are better-tested hypotheses’’*, *‘‘hypothesis influences theory’’* at level 2, *‘‘knowledge is not certain’’*, *‘‘there are hypotheses (alternative explanations)’’*, *‘‘verification/justification depends on the quality of evidence’’*, *‘‘correlation with evidence/quality of evidence is important’’*, *‘‘alternative explanation can be improved’’* at level 2.5, and *‘‘knowledge is not certain’’*, *‘‘depends on the strength of both evidence and theory’’* at level 3.

The coding related to scientific disagreements about an original scientific event in the third section are *‘‘it is due to their lack of proper knowledge’’*, *‘‘it is due to their mistakes and ignorance’’*, *‘‘the solution is attained by gathering more information and checking where mistakes are made’’* at level 1, *‘‘disagreements may be due to insufficient data and different attitudes towards the phenomena’’*, *‘‘different answers can be given to phenomenal problems’’*, *‘‘the importance of ideas is recognized’’* at level 1.5, *‘‘the solution to disagreements lies in accessing different data and findings; addressing different aspects of the issue; getting scientists to work together; reducing the hypotheses tested and making simpler comparisons’’* at level 2, *‘‘there can be many uncontrollable variables’’*, *‘‘data can be completely misinterpreted’’*, *‘‘these situations can be the basis for disagreements’’* at level 2.5, and *‘‘the scientists may have different competing theories. This situation can be the basis for the disagreement’’*, *‘‘idea/ideas (especially theories) are at the center’’*, *‘‘it is necessary to conduct experimental studies for evaluation’’* at level 3.

In the study, the data were analyzed on five levels and coded as level 1, level 1.5, level 2, level 2.5, and level 3. The levels can be broadly categorized as shown in Figure 1 below.

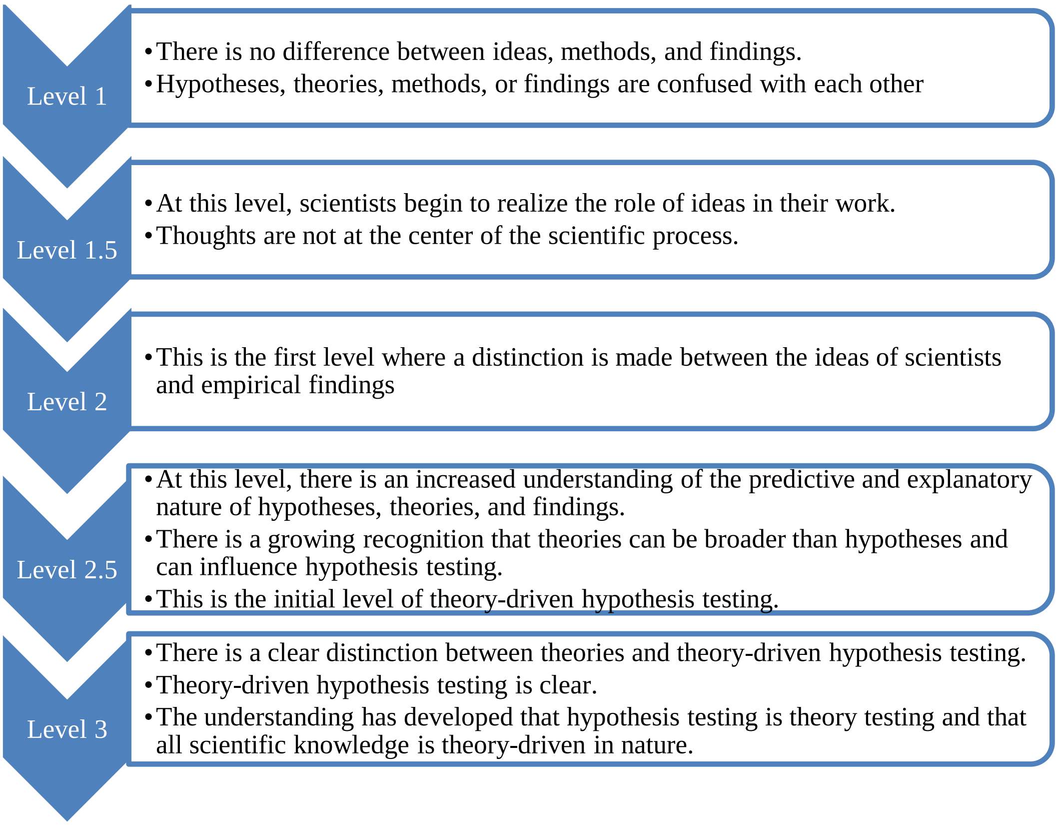

Figure 1. General classification of levels

The data were analyzed according to the Miles and Huberman (1994) model, which aims to explain the requirements of social phenomena. According to this model, the analysis includes three stages; organizing or reducing the data, displaying the data, and describing and verifying the results. In the process of analyzing qualitative data, the reliability formula Reliability=Agreement/(Agreement + Disagreement) was used and the consistency between different coders was found to be 89.9%. This result shows that the results are reliable (Baltacı, 2017).

3. FINDINGS

In this part of the study, the analysis and findings of the data collected from the semi-structured interview form will be presented. The views of the preservice teachers participating in the study on the nature of science were analyzed and the levels of preservice teachers (P.T.) are given in detail in Table 1.

Table 1. Findings related to the nature of science

Section	Subject	Level									
		1		1.5		2		2.5		3	
		P.T.	f	P.T.	f	P.T.	f	P.T	f	P.T	f
First section	The goal of science	P.T.1, P.T.2, P.T.3, P.T.4, P.T.6, P.T.7, P.T.9, P.T.10, P.T.11,P.T.12, P.T.13,P.T.14, P.T.15,P.T.16, P.T.17,P.T.21,P.T.24	17	P.T.8,P.T.18, P.T.19,P.T.22	4	P.T.5, P.T.20	2				

	The structure of scientific questions	P.T.1, P.T.2, P.T.3, Ö7, P.T.9, P.T.10, P.T.11,P.T.12, P.T.15,P.T.17, P.T.24	11	P.T.4, P.T.6, P.T.14, P.T.16, P.T.18, P.T.21,P.T.22	7	P.T.5, P.T.8, P.T.13, P.T.19, P.T.20, P.T.23	6	
	The nature of the experimental process	P.T.1,P.T.2, P.T.6,P.T.8, P.T.10,P.T.11, P.T.12,P.T.14, P.T.15,P.T.16, P.T.17, P.T.23	12	P.T.3, P.T.7, P.T.9, P.T.13, P.T.19, P.T.21,P.T.24	7	P.T.4, P.T.5, P.T.18, P.T.20, P.T.22	5	
	The nature of hypotheses and theories	P.T.1, P.T.6, P.T.7, P.T.8, P.T.10,P.T.14,P.T.15,P.T.17, P.T.24	9	P.T.2, P.T.3, P.T.4, P.T.9, P.T.12, P.T.13, P.T.16, P.T.18, P.T.21	9	P.T.5, P.T.11, P.T.19, P.T.20, P.T.23, P.T.22	6	
	The relationship between hypotheses and theories	P.T.1, P.T.3, P.T.7, P.T.8, P.T.10,P.T.12, P.T.14	7	P.T.2, P.T.4, P.T.6, P.T.9, P.T.11, P.T.13, P.T.15, P.T.16, P.T.17, P.T.18, P.T.21, P.T.22,P.T.23, P.T.24	14	P.T.5, P.T.19, P.T.20	3	
	The process related to the change of hypotheses and theories	P.T.7, P.T.12, P.T.13,P.T.14, P.T.18, P.T.24	6	P.T.2, P.T.3, P.T.6, P.T.8, P.T.9, P.T.10, P.T.11, P.T.15, P.T.16, P.T.17, P.T.19, P.T.20, P.T.21, P.T.22, P.T.23	15	P.T.1, P.T.4, P.T.5	3	
Second section	**Scientific accuracy**	P.T.8,P.T.11, P.T.12,P.T.15, P.T.17,P.T.21, P.T.23	7	P.T.1, P.T.3, P.T.4, P.T.5, P.T.6, P.T.7, P.T.9, P.T.10, P.T.13, P.T.14, P.T.19, P.T.22, P.T.24	13	P.T.2, P.T.16, P.T.18, P.T.20	4	
Third section	**Original scientific event**	P.T.4, P.T.6, P.T.8, P.T.16	4	P.T.1, P.T.2, P.T.3, P.T.7, P.T.10, P.T.12, P.T.13, P.T.14, P.T.15, P.T.17, P.T.18, P.T.19, P.T.21, P.T.22, P.T.24	15	P.T.5, P.T.9, P.T.11, P.T.20	4	P.T. 23

When Table 1 is analyzed, there are 17 preservice teachers at level 1, 4 preservice teachers at level 1.5, and 2 preservice teachers at level 2. There are no preservice teachers at level 2.5 and level 3. One preservice teacher was placed between *level 1.5* and *level 2*. The opinions of the preservice teachers at level 1 about the goal of science are as follows:

P.T.1: 'The goal of science is *to reach knowledge that will benefit people*. We can call *everything that makes people's lives easier*, science. *Reaching the undiscovered* can involve new methods, new techniques, I don't know, *technology*.'

P.T.7: 'I think the goal of science is to *produce a product that is… well... useful to people*, to do things that will benefit people. I mean, if you want to me give an example, well… for example, *the discovery of a wheel*, *the discovery of a computer*, all of these are *for the benefit of people, so I see science as a benefit arising from the need.*'

The extract regarding the opinion of the preservice teachers at level 1.5 about the goal of science is given below:

'P.T.22: "I think the goal of science is to try to explain the events in the universe *according to cause and effect*, this is the goal of science. Scientists need to be good observers of cause and effect.

As I said, first and foremost they need to have good observations, they need to follow their curiosity as a result of their observations, and they need to have established certain things. For example, observation, observation is not enough, it also needs to be analyzed. You need to think a little bit about *how it happened, why is that*, is that why it happened, you need to think a little bit further, distantly. You need to look at it from many perspectives, not just one way...'

The preservice teachers at Level 1 in regards to the goal of science, discussed *what* science is, emphasized the *concrete* features of science, and tried to make explanations *to describe* the situation. Therefore, they were included in Level 1. The preservice teachers at level 1.5 focused on *how and why* questions. They think about how the universe works and how the process functions, but they cannot give *examples* of what they mean by these thoughts or how the process works. Thus, they are placed at level 1.5.

The opinion of the preservice teacher at the additional level (1.5 and 2) is as follows:

P.T.23: 'To do research and explore the world and nature in a way that benefits humanity, I mean to beneficial to humanity. The *first thing that came to my mind was experiment*. *Experimental observations* came to mind. A certain systematic progress, moving forward with facts and scientific goals came to mind. What kind of things do they do? For example, finding something undiscovered, inventions, or finding the cause and treatment of a disease came to mind. For example, we didn't know about television, we didn't know about the planets. Uncovering something unknown, something that actually exists but is not known...'

When the opinion of participant P.T.23 is analyzed, it can be said that the participant also referred to level 1 and level 1.5. Because the participant also complies with the coding belonging to level 1 and level 1.5. However, participant P.T.23 not only makes references to experiments and observations but also gives examples about them. Therefore, it was also thought that the participant could be at level 2. When all the conditions were analyzed, it was seen that P.T.23 could not make a complete distinction between ideas and experimental findings, as well as mentioning observations and experiments, and so was placed in this additional level (1.5-2).

Table 1 shows the levels of preservice teachers regarding the structure of scientific questions. According to the findings, there were 11 preservice teachers at level 1, 7 at level 1.5, and 6 at level 2. The preservice teachers could not be placed at levels 2.5 and 3.

The opinion of P.T.15, who is one of the participants at Level 1, is as follows:

P.T.15: 'The structure of scientific question can be what should I do *to be useful* or what should I do *to go down in history*...'

The opinion of P.T.6, who is one of the preservice teachers at level 1.5, is as follows:

P.T.6: 'The secret of life from yesterday to the present, *how much more human life can be lived*. *Immortality if are thinking utopian*. How long we can go on...'

Regarding the structure of scientific questions, the preservice teachers at level 1 shared a common view that scientific questions focus on *''what''* questions and therefore were included in level 1. It is seen that the preservice teachers at level 1.5 focused on *''how''* questions, but they had difficulty giving *original examples* for these questions. The preservice teachers tried to explain how phenomena work or how one variable affects another variable and so they were placed at level 1.5. On the other hand, the preservice teachers at level 2, not only used the *''how''* question but also gave *original examples* for it. In addition, the preservice teachers were able to make deductions about how phenomena occur, and thus they were at level 2.

When Table 1 is examined, there are 12 preservice teachers at level 1, 7 at level 1.5, and 5 at level 2 regarding the nature of the experimental process. There are no preservice teachers at levels 2.5 and 3.

The opinion of one of the preservice teachers at level 1 is as follows:

P.T.8: 'The experiment is to make some problems more tangible to reveal them, to materialize them through experimentation...'

The opinion of one of the preservice teachers at level 1.5 is as follows:

P.T.21: 'It's a method... well... by which scientists check that what they think, I mean whether the environment always gives the same result given the same conditions. But for this to happen, for an experiment to happen, the conditions for the experiment must always kept the same, I mean, it is tested to see if it always gives the same result under the same conditions. Well, how effective is the thing that they develop or they produce...'

Regarding the nature of the experimental process, preservice teachers at level 1 were aware of what the experimental process means and that *data about phenomena and the external world can be obtained* at the end of the process and so they were placed at level 1. The preservice teachers at level 1.5 were united in the view that scientists work with phenomena in the experimental process, the experimental process is *observable*, and variables are *measurable* and *comparable*. The preservice teachers at level 2 agreed that the determining source of the experimental process is *the testing of hypotheses* and so they were placed at level 2.

When Table 1 is analyzed, there are 9 preservice teachers at level 1, 9 at level 1.5 and 6 at level 2 regarding the nature of hypotheses and theories. There are no preservice teachers at levels 2.5 and 3.

The following extract represents the opinion of the preservice teachers at level 1:

P.T.1: '…Well, what is a hypothesis? They throw out a hypothesis that hasn't been proven to be true yet, but it could be something like that... A scientific theory, well... for example, should I explain it with the law? For example, there is the law of gravity, it's a law, but when you say why gravity occurs, well... it's a theory, you know what I mean?'

The extract exemplifying the opinion of the preservice teachers at level 1.5 is as follows:

P.T.13: 'A hypothesis is knowledge that has not been proven to be true, that is, well... knowledge that has not been proven to be true, but which they produce... A theory can be knowledge based on a scientific fact, but it has not been proven to be true. It may be based on a scientific fact, but it may be an unproven fact...'

Regarding the nature of hypotheses and theories, the preservice teachers at level 1 do not know the meanings of the concepts of hypothesis and theory, what the difference between these concepts is, and they interpret these concepts as the thoughts of scientists. Therefore, they were placed at level 1. The preservice teachers at level 1.5 made explanations about hypotheses, but there were no statements that hypotheses could be tested through experiments. They considered theories as simple facts or predictions and so they were placed at level 1.5.

When Table 1 is examined, there are 7 preservice teachers at level 1, 14 preservice teachers at level 1.5, and 3 preservice teachers at level 2 regarding the relationship between hypotheses and theories. There are no preservice teachers at levels 2.5 and 3.

The extract exemplifying the opinion of the preservice teachers at level 1 is as follows:

P.T.7: 'Of course, they are in a relationship as long as they are in science, but I don't have much knowledge to explain their relationship... For example, we propose a theory. We can call it a theory only if when we have some data, you know what I mean, and a hypothesis has some data that has not been proven to be true but can be used, so I think they are related to each other in this way... If a scientist is doing a scientific study, at first, he or she starts with theories. They have some goals and some ideas that they present. As they collect this data, well... a hypothesis begins to take its form.'

The extract regarding the opinion of a preservice teacher at level 1.5 is as follows:

P.T.21: 'Yes, it is related. I know that the closer the hypothesis is to the truth, I mean that is what I know, the more it becomes a theory, the more it becomes a generalized knowledge, but I could be wrong. Does it affect the hypotheses they will test? It does. Since theories are products based on assumptions, since hypotheses are not precise information, I mean hypotheses are also based on assumptions, I think these two are things that will closely affect each other. Their common denominator...'

Regarding the relationship between hypotheses and theories, the answers of the preservice teachers at level 1 *were not consistent* and some preservice teachers *made similar explanations* about hypothesis and theory so they were placed at level 1. The preservice teachers at level 1.5 see hypothesis and theory as *different concepts* and in their definitions, they see hypothesis as *prediction* and theory as *findings or facts* and thus they are placed at level 1.5. The preservice teachers at level 2 were united under the view that theories are *better-tested hypotheses* and that *theories are influenced by hypotheses* and so they were placed at level 2.

When Table 1 is examined, there are 6 preservice teachers at level 1, 15 at level 1.5, and 3 at level 2 in regards to the process of changing hypotheses and theories. There are no preservice teachers at levels 2.5 and 3.

The extract exemplifying the views of the preservice teachers at level 1 is as follows:

P.T.13: 'Of course, if they think that they are going in the wrong direction in their experiments, for example, he or she made a hypothesis and did an experiment about it, but realized that it was going in the wrong direction, then he or she can change that. He or she can change his or her hypothesis to fit the experiment. It is easier to change the theory. Because an idea, an idea that has been put out there can be changed, another idea can probably be produced, but since the hypothesis is based on scientific knowledge, I think it will be more difficult to change it.'

The extract regarding the opinion of the preservice teachers at level 1.5 is as follows:

P.T.17: '…For example, the hypothesis or theory may not answer all the results in line with the results of the findings, or the hypothesis may be more comprehensive than the theory. So how can I say, well... let's say I have a hypothesis; I am researching bones, but in line with the results, I find a connection between bones and muscles rather than just knowledge of bones. I mean this does not complete my hypothesis into a theory, but it reveals missing points of my theory, emerges a new point of curiosity, I need to go to a new point, and I need to establish a new hypothesis for this, I mean, the hypothesis should always be… well, it may not be enough, we may need to change it. So, the hypothesis is something that is done when we start, and the theory, as I said, is the result of the accumulation of knowledge, research, labor, and expenses. In line with these results, the whole world accepts that it is a theory, so we can say that the hypothesis, for example, in the beginning, in line with our curiosity, we can say that... well... I made this hypothesis, tomorrow I can come and say that I want to change my hypothesis. But we cannot say such a thing to the theory, for the theory, time must pass, a lot of time must pass...'

Regarding the process for the change of hypotheses and theories, the preservice teachers at level 1 commented that certain *changes can occur* when mistakes are made in the experimental process and so they were placed at level 1. The preservice teachers at level 1.5 think that *if a change will occur* in the experimental process, it is *through findings or facts* and that *hypotheses can change and theories cannot because they are more difficult to prove*. They argued that the researcher can realize change when he or she makes mistakes in the process and is aware of this situation and thus they were placed at level 1.5. The preservice teachers at level 2 stated that *change in the experimental process is the process of testing hypotheses*, and although they could not distinguish between easiness and difficulty in the process of hypothesis and theory change, some preservice teachers commented that hypotheses may be easier to change than theories. Therefore, they were placed at level 2.

When Table 1 is examined, it is seen that there are 7 preservice teachers at level 1, 13 at level 1.5, and 4 at level 2, while there are no preservice teachers at levels 2.5 and 3.

The extract exemplifying the opinion of the preservice teachers at level 1 is as follows:

P.T.11: ‘Science can know the right answers, yes it can. Because science is something that investigates something in every aspect, goes deeper, but tries to reach a knowledge with many methods, even if it is wrong... That's why I agree that science produces clearer and more precise results...’

The extract regarding the statements of the preservice teachers at level 1.5 is as follows:

P.T.7: ‘Well, for example, some things in science have sometimes been considered true according to certain periods; but as technology has developed, we have seen that these are not true, but there are other truths. That's why I say yes to this for the period we are living in. But I also think that it can change in the future, so I think that it can know the truths for the period we are living in, but not the truths for all times... Well, in areas where the right answers do not arise, of course, people may not all think the same, after all, there is no right answer. Well, it is said that it is as good as the thoughts of other individuals. Yes, I agree. As an opinion, of course, yes, everyone's opinion is valuable. I mean, well... there are no right answers yet, so everyone can propose an idea. Of course, through all these, I mean, some people can give the right answers that can be observed, so yes, I think they are all good and right...’

Regarding scientific accuracy, the preservice teachers at level 1 stated that science can reach certain results and so they were placed at level 1. The preservice teachers at level 1.5 agreed that science can give certain results in some areas and *uncertain results in others*, and in the case of uncertainty, the results that are reported *by the majority of scientists can be considered correct* and thus they were placed at level 1.5. The preservice teachers at level 2 commented that *knowledge is not certain* and that evidence and data can be collected by inductive methods to find existing contradictions. Therefore, they were placed at level 2.

When Table 1 is analyzed, there are 4 preservice teachers at level 1, 15 preservice teachers at level 1.5, 4 preservice teachers at level 2, and 1 preservice teacher at level 2.5. There are no preservice teachers at level 3.

The extract regarding the opinion of the preservice teachers at level 1 is as follows:

P.T.6: ‘...The contradiction is that they did two scientific studies. They both said the same thing, this is a contradiction, which means there is a problem in the scientific justification of one of them, and there is a problem in the study. Well, there may be a problem when it does not reduce tooth cavities, or if it says that it reduces tooth cavities, you know, flour, flour is the one thing that should be examined, is flour really beneficial to the teeth? What is important is when the flour substance is really examined... oh I see, well... the bottom one says that it reduces tooth cavities, so they may have examined fluorine. Since they questioned whether flour has anything to do with dental health or at what stage flour is beneficial to the teeth, they may have revealed that what they say about reducing tooth cavities is wrong. On the top one, they may have proceeded from the general judgment that flour is good for teeth. But those who argue that it is wrong and does not reduce tooth cavities may be more logical. Because they have studied flour... they may have studied flour.’

When the opinions of the prospective teachers based on scientific disagreements about an original event were taken into consideration, the preservice teachers at level 1 expressed a common opinion that scientific disagreements may be due to people *not having the right information, person-based errors and misconceptions,* and that such misconceptions can be eliminated by *collecting more information* and controlling errors, and thus they were placed at level 1. The preservice teachers at level 1.5 commented that scientific disagreements could be due to *insufficient data collection* and *different attitudes towards phenomena* so they were placed at level 1.5. The preservice teachers at level 2 thought that scientific disagreements could be eliminated by *scientists working together, reaching different data and findings*, and *making simplified comparisons*, so they were placed at level

2. *The preservice teacher at level 2.5* expressed that the reason for scientific disagreements may be *uncontrollable variables*. In line with this opinion, the preservice teacher was placed at level 2.5.

4. DISCUSSION and CONCLUSION

The first finding of the study was that the majority of preservice teachers' perceptions of the nature of science were at level 1. It is observed that the responses of the preservice teachers at level 1 carry common views that the nature of science is suitable for answers aimed at producing concrete things; that it contains definitions to describe a situation; and that the nature of science answers the ‘‘what’’ question. There were no preservice teachers at levels 2.5 and 3. Based on this finding, it can be concluded that preservice teachers’ perceptions of the nature of science are inadequate. Studies in the literature also support this finding (Ayvacı & Muradoğlu, 2021; İrez, 2014; Khalick & Lederman 2000).

According to the findings of the study, it was observed that the majority of preservice teachers' perceptions of the structure of scientific questions were at level 1. The preservice teachers at level 1 agreed that the structure of scientific questions is oriented towards the ‘‘what’’ question. No preservice teacher could be placed at level 3 regarding the structure of scientific questions. Thus, based on the research findings and the literature (Doğan Bora, 2005), it can be concluded that preservice teachers' perceptions of the structure of scientific questions are at a low level. The nature of science seeks answers to questions about how science works (Köseoğlu et al., 2008). The nature of science asks and seeks answers to questions about how science works and how scientists carry out processes (Bilen & Köse, 2012). These questions may change and differentiate. Because science develops and grows in historical, political, and cultural environments and therefore scientific questions and the structure of scientific questions can change over time, place, and purpose (Cobern & Lovıng, 2002).

When the qualitative data obtained from the preservice teachers regarding the nature of the experimental process are analyzed, it is seen that the majority of them are at levels 1.5 and 2, respectively. While the preservice teachers at level 1.5 evaluate the nature of the experimental process as the measurement and comparison of directly observable variables, the preservice teachers at level 2 are united in the view that the experimental process is a hypothesis test. There were no preservice teachers at levels 2.5 and 3 regarding the nature of the experimental process. Based on the findings and the literature (Gürses, et al., 2005), it can be concluded that preservice teachers have a low level of understanding of the nature of the experimental process as well.

When the findings of the preservice teachers regarding the nature of hypotheses and theories are analyzed, it is observed that the majority of the preservice teachers are at levels 1.5 and 1, respectively. There are no preservice teachers at levels 2.5 and 3 in this domain as well. The preservice teachers at level 1.5 saw hypotheses as predictions based on knowledge and could not give answers as to how the predictions could be tested through experiments. It was also observed that they considered theories as predictions or simple facts. The preservice teachers at Level 1, on the other hand, did not know the meanings of the concepts of hypothesis and theory, and they considered these terms as the thoughts of scientists. Contrary to the low performance of the preservice teachers, ın the literature, it is stated that in order for a scientific explanation or set of propositions to be characterized as a theory, it should be tested again with experiments and expanded or narrowed when necessary. (Taşkın et al., 2008). In this context, theories are high-level scientific explanations that represent explanations based on logic, are supported by various evidences, and have validity. Again, theories are supported propositions that can explain certain aspects of nature; they are cognitive structures based on systematic observations and supported by evidence (Bilen & Köse, 2012). Based on the findings and the literature (Apaydın & Sürmeli, 2009), it can be concluded that preservice teachers exhibit a low level of understanding of the nature of hypotheses and theories.

When the pre-service teachers' responses to the dimension related to the relationship between hypotheses and theories were analyzed, it was found that most of them were at level 1.5. Although preservice teachers at level 1.5 see hypotheses and theories as different concepts, they think that hypotheses are predictions and theories are findings and facts. There are no preservice teachers at levels 2.5 and 3 in this domain as well. Most of the studies in the literature show that concepts such as law, theory, and hypothesis are often confused by the participants of the studies (Bilen & Köse, 2012). This situation creates a lot of problems in the perception of the nature of science (Taşkın et al., 2008). In this context, it can not be said that there is a sharp hierarchical relationship between the terms hypothesis, theory, and law in science. Scientific theories should be subjected to meticulous scrutiny at the stages of being constructed and supported, and they should exhibit a high level of internal and external consistency. Theories also have a special importance in terms of providing the necessary conditions for developing new studies and guiding them as well (Taşkın et al., 2008). Based on the literature and the findings, it can be concluded that preservice teachers could not fully comprehend the relationship between the conceptual terms of hypothesis and theory, and thus their comprehension levels were low. The literature supports this finding (Çakıcı 2009; Çınar & Köksal 2013).

When the findings regarding the process related to the change of hypotheses and theories are analyzed, it can be seen that most of the preservice teachers are at level 1.5. The preservice teachers at level 1.5 argued that hypotheses can change, theories cannot change because they are proven facts, and change can be realized through findings and facts. There were no preservice teachers at levels 2.5 and 3. Similarly, Gürses et al. (2005) stated in their study that the participant students argued that theories can change and laws cannot change. In addition, students are reported to have a lack of knowledge and misconceptions about theory, law and evidence. Findings in this regard (Erdoğan, 2004) are in parallel with the findings of our study.

When the findings related to scientific accuracy are analyzed, it is observed that most of the preservice teachers were at level 1.5. The preservice teachers at level 1.5 were united in their views that scientific knowledge can be certain in some areas and cannot be certain in others, and in cases of uncertainty, beliefs or majority opinions can be accepted. There were no preservice teachers at levels 2.5 and 3. However, contrary to the views proposed by the participant preservice teachers, scientific knowledge is of a nature that is not certain in its accuracy and has a changeable nature. In this sense, scientific action and the phenomenon of science have a nature that is open to constant change and development (Çakıcı, 2009). Based on the findings of the study and the literature (Craven et al., 2002, Doğan Bora, 2005; Yakmacı, 1998), it can be concluded that preservice teachers' level of comprehension about scientific accuracy is also low.

When the qualitative data on a unique phenomenal problem provided by the participant preservice teachers are analyzed, it is observed that the majority of them are at level 1.5. It is seen that the preservice teachers at level 1.5 are united in their views that the reasons for scientists' disagreement are based on the lack of sufficient data and that they have different attitudes towards phenomena or events. In this case, it can be concluded that the participants' level of comprehension of a unique phenomenal situation is also low. Studies in the literature also support this finding (Gürses et al., 2005).

Based on the statements mentioned above, it can be argued that the competence to comprehend the nature of science is very important, especially for preservice teachers who will take the responsibility of teaching science and natural sciences. Therefore;

- It can be concluded that higher education teacher training programs should be reorganized in the context of preservice teachers' gaining competence in epistemological beliefs and the concept of the nature of science.
- The content of science courses in faculties of education can be expanded. Pre-service teachers can be compared with case studies in science-oriented courses and they can be made to realize

applications with different methods and techniques (case study method, drama, argumentation, etc.).

- Course contents can be enriched with contemporary approaches to increase the knowledge of pre-service teachers about the goal of science, the structure of scientific questions and the nature of the experimental process.
- In order to increase the knowledge level of pre-service teachers about the concepts of hypothesis and theory, courses can be taught with contemporary methods by emphasizing misconceptions in the scientific research methods course in faculties of education so as not to create misconceptions.
- Designs can be made for pre-service teachers to realize in-class applications and pre-service teachers' experiences with students can be increased.
- It is expected that this study may contribute to other studies to be conducted on preservice teachers' nature of science and epistemological beliefs.

Ethics Committee Decision

This research was carried out with the permission of Ondokuz Mayıs University Publication Ethics Board with the session numbered 2023/517 dated 26.05.2023.

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