INVESTIGATION OF THE RELATIONSHIP BETWEEN PRE-SERVICE SCIENCE TEACHERS' UNDERSTANDINGS OF NATURE OF SCIENCE AND THEIR PERSONAL CHARACTERISTICS

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ABSTRACT

INVESTIGATION OF THE RELATIONSHIP BETWEEN PRE-SERVICE SCIENCE TEACHERS' UNDERSTANDINGS OF NATURE OF SCIENCE AND THEIR PERSONAL CHARACTERISTICS

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The purpose of this study was to investigate the possible relationships between pre-service science teachers' understanding of nature of science (NOS) and their personal characteristics; understanding of nature of scientific inquiry (NOSI), epistemological world views, self-efficacy beliefs regarding science teaching, attitudes towards science teaching, metacognitive awareness level and faith/worldview schemas. The sample of the present study were 60 PSTs that are 3rd year students at elementary science education department at a public university in the Marmara region. The sample was chosen by using purposive sampling from the PSTs enrolled in the "Nature of Science and History of Science" course. Using a descriptive and associational case study design PSTs' understandings of NOS, understanding of NOSI, epistemological world views, metacognitive awareness levels, self-efficacy beliefs, attitudes toward science teaching, and faith/worldviews were determined through different questionnaires and the associations between variables were investigated. Qualitative and quantitative questionnaires were analyzed and statistical analyses were conducted to see whether there is an association between PSTs' level of understanding of NOS and their personal characteristics. The results of the study revealed that PSTs understanding of NOS and NOSI were highly related. Similarly, self-efficacy beliefs regarding science teaching, metacognitive awareness levels and faith/worldviews of the PSTs were found to be significantly related to understanding of NOS. On the other hand, there were not any significant associations between PSTs' epistemological world views, attitudes towards science teaching and understanding of NOS.

Keywords: Nature of Science, Personal characteristics, Pre-service Science Teachers, Science Education

ÖZ

FEN BİLGİSİ ÖĞRETMEN ADAYLARININ BİLİMİN DOĞASI ANLAYIŞLARI VE KİŞİSEL ÖZELLİKLERİ ARASINDAKİ İLİŞKİNİN İNCELENMESİ

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Bu çalışmanın amacı fen bilgisi öğretmen adaylarının bilimin doğası anlayışlarıyla bilimsel sorgulamanın doğası anlayışları, epistemolojik dünya görüşü, fen öğretimine yönelik öz-yeterlik inançları, fen öğretimine yönelik tutumları, üstbilişsel farkındalık düzeyleri, ve inanç/dünya görüşü şemaları arasındaki ilişkileri incelemektir. Çalışmaya Marmara Bölgesi'ndeki bir devlet üniversitesinde Fen Bilgisi Öğretmenliği anabilim dalında 3. sınıf öğrencisi olan 60 öğretmen adayı katılmıştır. Çalışmanın örneklemi amaçlı örnekleme yöntemi kullanılarak "Bilimin Doğası ve Bilim Tarihi" dersine kayıtlı öğrencilerden seçilmiştir. Betimsel ve ilişkisel durum çalışması yöntemi kullanılarak öğretmen adaylarının bilimin doğası anlayışları, bilimsel sorgulamanın doğası anlayışları, epistemolojik dünya görüşleri, fen öğretimine yönelik öz-yeterlik inançları, fen öğretimine yönelik tutumları, üstbilişsel farkındalık düzeyleri, ve inanç/dünya görüşü şemaları farklı ölçekler ve anketler yardımıyla belirlenmiş ve değişkenler arasındaki ilişkiler incelenmiştir. Nitel ve nicel ölçekler analiz edildikten sonra farklı düzeyde bilimin doğası anlayışına fen bilgisi öğretmen adaylarının kişisel özelliklerine göre de farklılık gösterip göstermediğini incelemek amacıyla istatistiksel analizler yapılmıştır. Bu çalışmanın sonuçları fen bilgisi öğretmen adaylarının bilimin doğası ve bilimsel sorgulamanın doğası anlayışlarının yüksek ölçüde ilişkili olduğunu göstermiştir. Benzer şekilde, katılımcıların fen öğretimine yönelik öz-yeterlik inançları, üstbilişsel farkındalık düzeyleri, ve inanç/dünya görüşü şemaları da bilimin doğası anlayışlarına anlamlı bir şekilde ilişkili bulunmuştur. Buna karşılık, katılımcıların bilimin doğası anlayışları, epistemolojik dünya görüşleri ve fen öğretimine yönelik tutumları arasında bir ilişki bulunmamıştır.

Anahtar Kelimeler: Bilimin Doğası, Kişisel Özellikler, Fen Bilgisi Öğretmen Adayları, Fen Eğitimi

To my dearest mother
Nebile ÇETİNKAYA

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LIST OF ABBREVIATIONS

NSTA : National Science Teachers Association
NRC : National Research Council
MoNE : Ministry of National Education
PST : Pre-service Science Teacher
NOS : Nature of Science
SI : Scientific inquiry
NOSI : Nature of Scientific Inquiry
VNOS : Views of Nature of Science
VOSI : Views of Scientific Inquiry
EWVS : Epistemological World Views Scale
STEBI : Science Teaching Efficacy Belief Instrument
PSTE : Personal Science Teaching Efficacy Beliefs
STOE : Science Teaching Outcome Expectancy
STAS : Science Teaching Attitudes Scale
MAI : Metacognitive Awareness Inventory
KoC : Knowledge of Cognition
RoC : Regulation of Cognition
SFWS : Scale of Faith or Worldview Schemas
POSE : Perspectives on Scientific Epistemology
NSKS : Nature of Scientific Knowledge Scale
TOUS : Test of Understanding Science
VOSTS : Views on Science-Technology-Society

CHAPTER 1

INTRODUCTION

Scientific literacy has been identified as the main goal of science education by National Science Teachers Association (NSTA) in 1971; however, since it is a broad concept that is associated with many educational themes changing over time, a single precise definition of the term could not be agreed upon (DeBoer, 2000). One of the most broad and clear definition of the term was introduced in *the National Science Education Standards* by National Research Council (NRC) (1996) as:

> Scientific literacy means that a person can ask, find, or determine answers to questions derived from curiosity about everyday experiences. It means that a person has the ability to describe, explain, and predict natural phenomena. Scientific literacy entails being able to read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions. Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed. A literate citizen should be able to evaluate the quality of scientific information on the basis of its source and the methods used to generate it. Scientific literacy also implies the capacity to pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately (NRC, 1996, p. 22).

In science education, understanding the nature of science (NOS) is accepted as a crucial component of scientific literacy which requires being able to not only understand science content but also develop ideas for how science proceeds and how scientists work along with their values, beliefs and assumptions (Akerson, & Buzzelli, 2007). It has been identified as an important and critical learner outcome by various science education documents all around the world including Australia, Canada, South Africa, United Kingdom, USA (Lederman, 2007). Similarly, in Turkey, the latest science and technology program placed great emphasis on the development of scientific literacy and understanding of the nature of science (Ministry of National Education [MoNE], 2004). Deniz (2007) addressed the importance of NOS understanding on three grounds: (1) curricular; adequate NOS understanding will help students to have a general background knowledge in all science subjects, (2) democratic; citizens of a democratic society should be scientifically literate and able to make decisions about controversial issues in science, and (3) pedagogical; students' understanding of NOS can affect their learning of certain science content.

In spite of the fact that the importance of NOS has been strongly emphasized in the science education literature, there are various different definitions of the term nature of science and no single definition is accepted as the correct one. One of the most cited definitions of the term NOS was made by Lederman (1992) as “the epistemology of science, science as a way of knowing, or values and beliefs inherent to the development of scientific knowledge” (p. 331). In his review, Abd-El-Khalick (2012) identified two different perspectives situating NOS: lived perspective and reflective perspective. Lived perspective argues that NOS is scientific practice and only be acquired through practice, implicitly. NOS learning is the product of engagement in science activities. On the other hand, reflective perspective suggests that, NOS is about the practice of science and cannot be learned implicitly by simply doing science. NOS should be addressed in the science curriculum consciously through structured reflection on practice.

Although a single universally accepted definition of the term NOS is missing and there are different perspectives about NOS and its learning, there is an agreement on some general aspects of NOS that should be known by teachers, students and all scientifically literate people. Table 1.1. presents the descriptions of these aspects provided by Schwartz, Lederman, and Crawford (2004, p. 613).

Table 1.1. NOS Aspects and Descriptions that Served as a Basis for Comparison

Aspect	Description
Tentativeness	Scientific knowledge is subject to change with new observations and with the reinterpretations of existing observations. All other aspects of NOS provide rationale for the tentativeness of scientific knowledge.
Empirical basis	Scientific knowledge is based on and/or derived from observations of the natural world.
Subjectivity	Science is influenced and driven by the presently accepted scientific theories and laws. The development of questions, investigations, and interpretations of data are filtered through the lens of current theory. This is an unavoidable subjectivity that allows science to progress and remain consistent, yet also contributes to change in science when previous evidence is examined from the perspective of new knowledge. Personal subjectivity is also unavoidable. Personal values, agendas, and prior experiences dictate what and how scientists conduct their work.
Creativity	Scientific knowledge is created from human imaginations and logical reasoning. This creation is based on observations and inferences of the natural world.
Social & Cultural embeddedness	Science is a human endeavor and is influenced by the society and culture in which it is practiced. The values of the culture determine what and how science is conducted, interpreted, accepted, and utilized.
Observation and inference	Science is based on both observation and inference. Observations are gathered through human senses or extensions of those senses. Inferences are interpretations of those observations. Perspectives of current science and the scientist guide both observations and inferences. Multiple perspectives contribute to valid multiple interpretations of observations.
Laws and theories	Theories and laws are different kinds of scientific knowledge. Laws describe relationships, observed or perceived, of phenomena in nature. Theories are inferred explanations for natural phenomena and mechanisms for relationships among natural phenomena. Hypotheses in science may lead to either theories or laws with the accumulation of substantial supporting evidence and acceptance in the scientific community. Theories and laws do not progress into one and another, in the hierarchical sense, for they are distinctly and functionally different types of knowledge.

Source: Schwartz et al., 2004, p. 613.

In his comprehensive review of the literature regarding 50 years of research of NOS understanding of students and teachers, Lederman (2007) made five generalizations: (1) K-12 students generally do not have adequate understandings of NOS, (2) K-12 teachers generally do not have adequate understandings of NOS, (3) explicit-reflective instruction is better than implicit approach in supporting NOS understanding, (4) NOS understandings of teachers do not necessarily translated into their classroom practice, (5) teachers do not value NOS as an instructional outcome as they value traditional subject matter outcomes.

As a lot of studies revealed naïve views of learners, Lederman, Abd-El-Khalick, Bell, and Schwartz (2002, pp. 514-516) presented examples of naïve and informed views of NOS selected from the responses of college students, pre-service and in-service elementary and secondary science teachers to Views of Nature of Science Questionnaire (VNOS) items in their various different studies. Table 1.2. presents a summary of these naïve views of tentativeness, empirical basis, subjectivity, creativity, social and cultural embeddedness, observation and inferences, and laws and theories aspects of NOS.

Table 1.2. Examples of responses to VNOS items

NOS Aspect	More Naive Views	More Informed Views
Tentativeness	• If you get the same result over and over and over, then you become sure that your theory is a proven law, a fact. • Compared to philosophy and religion.. .science demands definitive ...right and wrong answers.	• Everything in science is subject to change with new evidence and interpretation of that evidence. We are never 100% sure about anything because ...negative evidence will call a theory or law into question, and possibly cause a modification.
Empirical basis	• Science is something that is straightforward and isn't a field of study that allows a lot of opinions, personal bias, or individual views—it is fact based. • Science is concerned with facts. We use observed facts to prove that theories are true.	• Much of the development of scientific knowledge depends on observation. ...[But] I think what we observe is a function of convention. I don't believe that the goal of science is (or should be) the accumulation of observable facts. Rather .. .science involves abstraction, one step of abstraction after another.
Creativity	• A scientist only uses imagination in collecting data... But there is no creativity after data collection because the scientist has to be objective.	• Logic plays a large role in the scientific process, but imagination and creativity are essential for the formulation of novel ideas ...to explain why the results were observed.
Subjectivity	• [Scientists reach different conclusions] because the scientists were not around when the dinosaurs became extinct, so no one witnessed what happened....I think the only way to give a satisfactory answer to the extinction of the dinosaurs is to go back in time to witness what happened. • Scientists are very objective because they have a set of procedures they use to solve their problems. Artists are more subjective, putting themselves into their work.	• Both conclusions are possible because there may be different interpretations of the same data. Different scientists may come up with different explanations based on their own education and background or what they feel are inconsistencies in others ideas. • Scientists are human. They learn and think differently, just like all people do. They interpret the same data sets differently because of the way they learn and think, and because of their prior knowledge.

Table 1.2. Examples of responses to VNOS items (cont'd)

Social & Cultural Embeddedness	• Science is about the facts and could not be influenced by cultures and society. Atoms are atoms here in the U.S. and are still atoms in Russia. • Well, the society can sometimes not fund some scientific research. So, in that sense it influences science. But scientific knowledge is universal and does not change from one place to another.	• Of course culture influence the ideas in science. It was more than a 100 years after Copernicus that his ideas were considered because religious beliefs of the church sort of favored the geocentric model. • All factors in society and the culture influence the acceptance of scientific ideas. ...Like the theory of evolution was not accepted in France and totally endorsed in Germany for basically national, social, and also cultural elements.
Observation and Inferences	• Scientists can see atoms with high-powered microscopes. They are very certain of the structure of atoms. You have to see something to be sure of it. • There is...scientific certainty [about the concept of species]. While in the early days it was probably a matter of trial-and-error ...nowadays genetic testing makes it possible to define a species precisely.	• Evidence is indirect and relates to things that we don't see directly. You can't answer.. .whether scientists know what the atom looks like, because it is more of a construct. • Species is ...a human creation. It is a convenient framework for categorizing things. ...It is a good system but I think the more they learn the more they realize that ...we cannot draw the line between species or subspecies.
Laws and Theories	• Laws started as theories and eventually became laws after repeated and proven demonstration. • A scientific law is somewhat set in stone, proven to be true ...A scientific theory is apt to change and be proven false at any time.	• A scientific law describes quantitative relationships between phenomena such as universal attraction between objects. Scientific theories are made of concepts that are in accordance with common observation or go beyond and propose new explanatory models for the world.

Source: Lederman et al., (2002), pp. 514-516.

Besides the studies focused on students' and teachers' understandings of NOS, the ways to improve effectiveness of NOS instruction, the relationship between teachers' understandings of NOS and classroom practice, in recent years, researchers have begun to investigate other factors that might have a relationship with learners' understanding of NOS. For example, Southerland, Johnston, and Sowell (2006) investigated several factors that might influence conceptualization of NOS and found that past science experiences, goals for learning, emotions regarding science played a role in their conceptual ecologies meditated through learning dispositions whereas religious beliefs of participants did not have an effect. In another study, Abd-El-Khalick and Akerson (2004) identified internalizing the importance of NOS, interaction of NOS instruction with global worldviews/religious beliefs and deep versus surface orientation to learning as the factors affecting the development of informed NOS views. Similarly, Akerson and Donnely (2008) found that cultural values and knowledge of cognition levels were related to level of NOS understanding. In their study, Roth and Alexander (1997) argued that when their scientific knowledge and religious beliefs contradicted with each other, students' strong religious beliefs cause them to have difficulties in gaining a meaningful understanding of NOS. Muğaloğlu and Bayram (2010) also claimed that pre-service science teachers having strong religious beliefs might feel a contradiction between religious explanations and scientific explanations of certain phenomena; therefore, they might be less eager to adopt a contemporary understanding of NOS. Moreover, Haidar (1999) also showed that pre-service and in-service teachers' views of NOS were influenced by their religious beliefs.

Inspired by the aforementioned studies, this study aimed to investigate the possible associations between pre-service science teachers' (PSTs) understanding of nature of science and their personal characteristics. In the present study, understanding of nature of scientific inquiry (NOSI), epistemological world views, self-efficacy beliefs regarding science teaching, attitudes towards science teaching, metacognitive awareness level and faith developments were identified as possible personal characteristics that might be related to NOS understanding.

Firstly, it was hypothesized that there is an association between pre-service science teachers' (PSTs) understanding of NOS and NOSI. Schwartz, Lederman, and Lederman (2008) stated that NOSI aspects were generally neglected or combined under a general headline as understanding of NOS; however, there were specific characteristics of scientific inquiry connected to nature of science aspects but should be distinguished and emphasized. In their comprehensive study, Lederman et al. (2003) found that teachers' views of NOS and NOSI improved together during explicit instruction and continuous support to teachers. Understanding of NOS and NOSI were considered to be parallel; as one improves the other one improves too. Moreover, researchers emphasize that doing scientific inquiry and understanding its nature is an important step for being able to understand the nature of science (Bell, Blair, Crawford, & Lederman, 2003). Therefore, PSTs with more informed views of NOS were expected to have more informed views of NOSI. For this reason the associations between PSTs understanding of NOS and NOSI were investigated.

Secondly, it was hypothesized that there is an association between PSTs' understanding of NOS and their epistemological worldviews. Tsai (2002) found that teachers' views of teaching and learning science related to their views of nature of science. Moreover, Aguirre, Haggerty and Linder (1990) and Gustafson and Rowell (1995) claimed some associations between science teachers’ views about learning, teaching and science. For this reason, the association between epistemological worldviews and understanding of NOS was investigated.

Thirdly, it was hypothesized that PSTs with different levels of NOS understanding would also differ in terms of their self-efficacy beliefs regarding science teaching. Hanson (2006) found that a more informed understanding of NOS increased personal science teaching self-efficacy. Moreover, Tekkaya, Çakıroğlu and Özkan (2004) and

Bleicher and Lindgren (2005) claimed that there is a relationship between science content knowledge and science teaching self-efficacy. Since NOS can be considered as a spesific science topic, there might be a relationship between science teaching self-efficacy and understanding of NOS.

Fourthly, it was hypothesized that PSTs with different levels of NOS understanding would also differ in terms of their attitudes towards science teaching. Muğaloğlu and Bayram (2010) found that PSTs' attitudes towards science teaching had a positive mediator effect on their NOS views.On the other hand, Harty, Samuel and Andersen (1991) found no significant correlations between understanding of NOS and attitudes toward science teaching. Therefore, the relationship between attitudes towards science teaching and understanding of NOS is inconclusive and further research is needed.

Fifthly, it was hypothesized that PSTs with different levels of NOS understanding would also differ in terms of their metacognitive awareness levels. Peters and Kitsantas (2010) claimed that the development of level of metacognition was effective in increasing students' understanding of NOS understanding. Moreover, Abd-El-Khalick and Akerson (2009) concluded that development of more informed understandings of NOS is related to higher levels of metacognitive awareness. Therefore, the differences in metacognitive awareness levels of PSTs with different levels of NOS understanding were investigated.

Lastly, it was hypothesized that PSTs with different levels of NOS understanding would also differ in terms of their faith development. Roth and Alexander (1997) claimed that students' strong religious beliefs negatively influenced their development of a meaningful understanding of NOS. Haidar (1999) and Abd-El-Khalick and Akerson (2004) also found that when individuals' religious beliefs contradict with NOS aspects, they cannot improve their NOS views. Therefore, a possible relationship between faiths and NOS understanding might exist and in the present study the differences in faith/worldview schemas of PSTs with different levels of NOS understanding were investigated.

1.1. Significance of the Study

Teachers are keys to help students develop appropriate views of NOS. Therefore, a major task for science teacher educators is to improve science teachers' understandings of NOS so they can help their own students develop appropriate ideas. If teachers do not understand the nature of science, it is impossible for them to teach appropriate views of NOS (Abd-El-Khalick, & Lederman, 2000). For this reason, several studies had conducted over the past several decades in order to test the effectiveness of different strategies in improving learners' NOS views (e.g. Akerson, Abd-El-Khalick, & Lederman, 2000; Akgül, 2006; Khishfe & Lederman, 2007; Lin & Chen, 2002; Meichtry, 1992; Schwartz, Lederman, & Crawford, 2004). However, despite these attempts to enhance teachers' NOS conceptions by improving instructional strategies, recent studies still reveal that learners having difficulties to develop adequate views of NOS (Lederman, 2007) and these difficulties have been found to be related to the characteristics of the learners (Akerson, & Donnelly, 2008).

Although the success of an instructional technique is proved, there might be some other factors affecting the process of teaching and learning. The present study seeks for an answer to the question whether there are some other factors independent from the quality of NOS instruction that might be related to pre-service science teachers' understanding of NOS or not. It is important to identify these personal characteristics in order to be able to plan an effective NOS instruction.

For this reason, the present study aims to determine personal characteristics and NOS understandings of a group of PSTs who received the same NOS instruction. The focus is on the NOS understanding because as it was mentioned before, it is a critical component of scientific literacy. Although there are many studies conducted in Turkey related to determining and improving NOS understanding of pre-service teachers, this study differs from them by trying to describe an existing situation, collecting various data from the same group of participants and providing a ground work for future studies related to factors affecting NOS understanding. It is important to know the possible factors that might have a relationship with understanding of NOS to be able to improve learners' NOS views.

The findings of this study would be informing for teachers, researchers and policy makers; while planning NOS instruction they would be aware of the fact that there would be other characteristics of the PSTs that would affect the efficiency of the instruction process. By this way, instruction of NOS, content, purposes and activities would be organized by taken into account these personal characteristics in order to improve the effectiveness of the instruction. If these characteristics were identified it would be easier to control and manage their influence on understanding of NOS. A positive relationship between NOS understanding and a characteristic might imply that this variable should also be tried to enhance to improve NOS understanding. On the other hand, a negative relationship between NOS understanding and a characteristic might imply that the influence of this variable should be minimized. In addition, the findings of this study would provide a ground work and reference for future studies regarding the ways of improving the quality of NOS instruction; by this way, researchers would be aware of the other variables that might influence the impact of their studies.

1.2. Definition of Important Terms

The definitions of important terms used in the present study are presented in this section.

Nature of Science: Lederman (1992) defined NOS as “the epistemology of science, science as a way of knowing, or values and beliefs inherent to the development of scientific knowledge” (p. 331). A person with an adequate understanding of NOS are expected to know aspects of tentativeness, subjectivity, empirical-basis, creativity, observation and inferences, theories and laws, and social and cultural embeddedness (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002).

Nature of Scientific Inquiry: Schwartz et al. (2008) defined scientific inquiry as "the characteristics of the processes through which scientific knowledge is developed, including the conventions of development, acceptance, and utility of scientific knowledge" (p. 3). They also identified seven nature of scientific inquiry (NOSI) aspects related to processes of scientific inquiry and how the knowledge is generated and accepted. These aspects are a) scientific questions guide investigations, b) multiple methods of scientific investigations, c) multiple purposes of scientific investigations, d) justification of scientific knowledge, e) recognition and handling of anomalous data, f) distinctions between data and evidence, and g) community of practice.

Epistemological World View: Schraw and Olafson (2002) defined the term epistemological world view as “a set of beliefs about knowledge and knowledge acquisition that influences the way teachers think and make important instructional decisions” (p. 99).

Science Teaching Self-Efficacy: Tschannen-Moran, Woolfolk Hoy and Hoy (1998) defined teacher self-efficacy as "teacher's belief in his or her own capability to organize and execute courses of action required to successfully accomplish a specific teaching task in a particular context" (p. 233).

Attitudes towards Science Teaching: Petty and Cacioppo (1981) defined an attitude as “a general and enduring positive or negative feeling about some person, object, or issue" (p. 7). Based on this definition attitudes towards science teaching might be considered as positive or negative feelings about science teaching.

Metacognitive Awareness: Schraw and Dennison (1994) defined metacognition as "the ability to reflect upon, understand, and control one's learning" (p. 460).

Faith/World View: Faith development theory, developed by Fowler (1974, 1981) defined faith as how God or a Higher being is conceptualized by people and tried to explain how this conception influences their meanings, values, beliefs, and relationships with others (Fowler, & Dell, 2006).

1.3. Purpose of the Study

The purpose of this study was to investigate the possible relationships between NOS understanding and other personal characteristics of PSTs who were enrolled in an elementary science education program offered at a public university in the Marmara region. Regarding the existing literature, understanding of nature of scientific inquiry, epistemological world views, self-efficacy beliefs regarding science teaching, attitudes towards science teaching, metacognitive awareness level and faith/worldview schemas were identified as specific personal characteristics and statistical analysis were conducted to see whether PSTs with different levels of understanding of NOS differ in terms of these personal characteristics.

1.4. Research Questions

1. What are pre-service science teachers' understandings of NOS?
2. What are pre-service science teachers' understandings of NOSI?
3. Is there an association between PSTs' understanding of NOS and NOSI?
4. Is there an association between PSTs' understanding of NOS and their epistemological world views?

5. Do PSTs with different levels of NOS understanding differ in terms of their self-efficacy beliefs regarding science teaching?
6. Do PSTs with different levels of NOS understanding differ in terms of their attitudes towards science teaching?
7. Do PSTs with different levels of NOS understanding differ in terms of their metacognitive awareness levels?
8. Do PSTs with different levels of NOS understanding differ in terms of their faith/worldview schemas?

CHAPTER 2

LITERATURE REVIEW

In order to frame this study, the review of the literature regarding nature of science and each of the other personal characteristics; views of scientific inquiry, epistemological world views, science teaching efficacy, attitude towards science teaching, metacognitive awareness, and faith/beliefs are presented in the following sections.

2.1. Nature of Science

In the Nature of Science position statement, NSTA (2000) suggested that all people involved with science as teachers or learners, should have an accurate, contemporary view of NOS and identified critical premises that should be known to understand NOS which can be summarized as:

- Scientific knowledge is both reliable and tentative.
- There is no single scientific method, but there are some shared values and perspectives characterizing the scientific approach.
- Creativity is a vital element during the production of scientific knowledge.
- Science is limited to naturalistic methods and explanations; the use of supernatural elements is excluded.
- Formation of theories and laws, which are interrelated but different concepts, is a primary goal of science.
- The existing scientific knowledge, social and cultural context, expectations and background of the researcher influence scientists' work.

- New evidences and re-interpretations of the old ones result in changes in science.
- Science and technology influences each other but practical outcomes are not the main concern of science.

Besides identifying critical characteristics of science and scientific knowledge, Abd-El-Khalick (2012) defined nature of science as an enterprise:

> NOS is a reflective endeavor: The varying images of science that have been constructed throughout the history of scientific enterprise are, by and large, the result of the collective scholarship of historians, philosophers, and sociologists of science, as well as scientists turned historians or philosophers, and reflective scientists. Representations of the scientific enterprise reflect the collective efforts of these scholars to reconstruct the history, activities, and practice of science in an attempt to understand its working and the nature of its products (Abd-El-Khalick, 2012, p. 1051).

The importance of NOS emphasized in science education literature for a long time. In the following sections, the literature regarding NOS is reviewed under five main headings; methods of teaching nature of science, students' understanding of nature of science, teachers' understanding of nature of science, pre-service teachers' understanding of nature of science and the relationship between NOS understanding and other personal characteristics which are the most common topics that have been focus of several studies about NOS.

2.1.1. Methods of Teaching Nature of Science

Contemporary reform efforts in science education have strongly emphasized the importance of developing accurate and adequate understanding of NOS; it has been considered to be a key component of scientific literacy and an important content that should be addressed in science instruction across all grade levels (Bell, Matkins, & Gansneder, 2011). Although the importance of NOS understanding is widely accepted, many previous studies (e.g. Bloom, 1989; Carey, & Stauss, 1968; Doğan, & Abd-El-Khalick, 2008; Griffiths, & Barman, 1995; Ryder, Leach, & Driver, 1999) showed that teachers, pre-service teachers and students had inadequate understanding of NOS. For this reason, numerous attempts have been tried to enhance learners' NOS understanding which can be categorized under three main approaches which are historical, implicit and explicit-reflective (Khishfe, & Abd-El-Khalick, 2002).

Firstly, Solomon, Duveen, Scot, and McCarthy (1992) argued that learning history of science provides learners a better learning of the concepts of science, increases their interest and motivation, serves as an introduction to the philosophy of science, develops a better attitude of the public towards science, and helps learners to understand the social relevance of science. Moreover, based on the results of their action research study they claimed that teaching the history of science within the normal school curriculum made favorable changes in pupils’ understanding of the nature of science. Mathews (1994), and Kim and Irving (2010) also suggested that teaching history of science can provide a better understanding of nature of science. On the other hand, there are also other studies investigated influence of historical approach on learners' NOS perceptions and claimed that it does not have a positive effect (Welch, & Walberg, 1972; Yager, & Wick, 1966). Therefore, it is hard to drive a conclusion about the effectiveness of historical approach in enhancing learners’ NOS understanding (Russell, 1981; Lederman, 2004).

Secondly, the implicit approach suggests that NOS understanding can be facilitated through process skill instruction, science content coursework, and doing science; but it excludes instructional processes (Abd-El-Khalick, & Lederman, 2000). However, as Khishfe and Abd-El-Khalick (2002) stated the results of various different studies revealed that implicit approach, engagement of learners in science-based inquiry activities and expecting them automatically develop a deeper understanding of NOS without making explicit references to NOS is not effective in enhancing learners' NOS understandings (e.g. Crumb, 1965; Tamir, 1972; Riley, 1979; Meichtry, 1992).

Lastly, the explicit-reflective approach takes learners' attention to features of NOS through instructional processes such as discussion, questioning, explicit messages, guided reflection, and examples from history and philosophy of science (Schwartz, Lederman, & Crawford, 2004). There are also two different approaches of explicit-reflective instruction: integrated and nonintegrated. Khishfe and Lederman (2006) described integrated approach in which NOS is presented within the science content; however, contrary to implicit approach it is planned and explicitly addressed in relation to science content. On the other hand, in nonintegrated approach NOS is addressed through specific NOS activities without any relation to science content.

Khishfe and Lederman (2006) also compared the effectiveness of integrated and nonintegrated approach in promoting NOS understanding. They conducted a study with 42 ninth grade students divided into two groups: integrated and nonintegrated. For six weeks, in the "integrated" group, NOS instruction was given within the science content about global warming, whereas in the "nonintegrated" group NOS instruction was given through a set of activities specifically addressing NOS issues. Data were collected through an open-ended questionnaire supported with semi-structured interviews, was used to assess students' views of tentativeness, empirical-basis, creativity, observations and inferences, and subjectivity aspects of NOS. The results showed that all of the participants developed more informed views of NOS regardless of the approach used; neither integrated nor nonintegrated approach was concluded to be more effective than the other. Both of the explicit approaches were concluded to be effective in developing informed views of NOS. The results of similar studies also showed that explicit approach is more successful in gaining a meaningful NOS understanding than historical and implicit approach (e.g. Abd-El-Khalick, 2001; Abd-El-Khalick, & Akerson, 2004; Akindehin, 1988; Carey, & Stauss, 1970; Khishfe, & Abd-El-Khalick, 2002); however, much can be done to enhance its effectiveness (Abd-El-Khalick, & Lederman, 2000; Lederman, 2004).

In conclusion, the results of most of the studies suggested that one of the best ways to teach nature of science is an explicit-reflective approach combined with classroom discussion, examples from history of science, laboratory exercises and socio-scientific issues (Akindehin, 1988; Matthews, 1998; Lederman, 2007).

2.1.2. Students' Understanding of Nature of Science

As accepted to be a critical component of scientific literacy, gaining students a meaningful understanding of NOS has been an important objective of science education (Abd-El-Khalick & Lederman, 2000; NSTA 1982). For this reason identifying students' understanding of NOS and assessing the effectiveness of different strategies on prompting students' understanding of NOS have been a popular research topic in science education, especially in the past few decades.

In their comprehensive review of the earlier years of the science education literature, Abd-El-Khalick and Lederman (2000) stated that regardless of the instruments used, it was consistently found that students held inadequate understanding of NOS (e.g. Aikenhead, 1973; Broadhurst, 1970; Lederman & O’Mally, 1990; Mackay, 1971; Rubba, 1977; Rubba, Horner, & Smith 1981; Tamir & Zohar, 1991; Wilson, 1954) even the most capable students with a high desire to learn about science. Abd-El-Khalick (2012) also supported this claim with recent studies, stating that elementary, middle, high school and college students all around the world are still found to be having naïve views of NOS (e.g. Doğan, & Abd-El-Khalick, 2008; Ibrahim, Buffler, & Lubben, 2009; Kang, Scharmann, & Noh 2005; Khishfe, & Abd-El-Khalick, 2002).

In their study, Bell, Blair, Crawford, and Lederman (2003) examined the effect of a 8-week science apprenticeship program on students’ understandings of NOS and scientific inquiry. A modified version of the VNOS-B questionnaire (Lederman, Abd-El-Khalick, Bell, Schwartz, & Akerson, 2002) was administered as pre- and post-test to ten volunteer high-ability secondary students and also semi-structured interviews were conducted. The modified version of the questionnaire included six questions from The VNOS-B and two additional questions designed to assess students' views of scientific inquiry. Results indicated that although most students gain knowledge about scientific inquiry, their understandings about key aspects of NOS did not change. They believed that scientific knowledge is based on empirical data and evidences, and scientific theories are tentative. However, they also believed that scientific theories could be proven, and scientific laws are absolute; cannot change. They also expressed inadequate ideas about the role of creativity in science by limiting the use of creativity to earlier stages of experiments. Moreover, although the students learned certain inquiry skills, they still believed that there is a single scientific method.

Kang, Scharmann and Noh (2005) conducted a large-scale survey with 6th, 8th, and 10th grade Korean students. The researchers administered a five-item questionnaire related to five constructs of NOS; the purpose of science, definition of a scientific theory, nature of models, tentativeness of scientific theories, and origin of scientific theories. Students were also asked for their rationales for their choices with an open-ended section for each item. The results of the study showed that majority of the students do not possess a contemporary understanding of the NOS constructs. Most of the students thought that science was "an activity concerned with making the world a better place to live in" (p. 323), scientific theories were "facts which have been proven by many experiments" (p. 325), scientific models were "proven to exist through many experiments" (p. 326), scientific theories change over time "as the results of falsifications by the development of technology and the growth of knowledge" (p. 328) and scientific theories were "out there to be known by scientists; scientists discover theories (i.e., facts) that already exist as objects" (p. 330).

A recent experimental study was conducted by Yacoubian and BouJaoude (2010) in Lebanon. The researchers investigated the effectiveness of inquiry-based laboratory activities followed by reflective discussions on students’ views of NOS. A pretest-posttest control group design was used with 38 sixth grade students. Eight laboratory activities were prepared for both of the groups; however, at the end of the activities, the students in experimental group were asked open-ended NOS questions individually followed by a reflective discussion about NOS with their peers. On the other hand, the students in the control group answered open-ended questions about the laboratory activities individually followed by a discussion about the results of the laboratory activities with their peers. As data sources an open-ended questionnaire entitled Perspectives on Scientific Epistemology Questionnaire (POSE) (Abd-El-Khalick, 2002) was used as pretest and posttest, experimental group students' responses to open-ended questions at the end of the laboratory sessions, videotapes of all class sessions and semi-structured interviews with a number of students from the experimental group were used. Students' understanding of the tentative, empirical, subjective, and social aspects of NOS were investigated during data analysis. Pre-test results showed that majority of the students held inadequate views of target NOS aspects before intervention and post-test results revealed that explicit and reflective discussions of NOS enhanced students' views of NOS whereas implicit instruction did not substantially improve students’ understanding of target NOS aspects. Moreover, the researchers concluded that although the laboratory activities meet the criteria to engage students in inquiry, they may not help students develop more informed views of NOS. The researchers also identified five challenges that students might face while trying to change their NOS views: Viewing science as a relative enterprise, differentiating among the components of inquiry, realizing the possibility of different explanations for the same phenomenon, viewing scientific experiments as tools rather than goals of science and viewing communication as a tool in the construction of scientific knowledge, and understanding the relation between personal learning of science and construction of scientific knowledge.

In a similar study, Akerson and Donnelly (2010) also investigated the effectiveness of a six-week Saturday Science program using explicit-reflective instruction through contextualized and decontextualized guided and authentic inquiry on enhancing NOS understandings of K-2 students. The participants of the study were a kindergarten students, nine first graders and eight second graders. Data were collected through interviews using the VNOS-D (Lederman, & Khishfe, 2002), copies of student work and videotapes of each week's science instruction. The results of the study showed that all of the students generally held inadequate views of NOS aspects prior to instruction but they improved their views after attending the program except the kindergarten student. Although they developed adequate views of the distinction between observation and inference, the creative NOS, the tentative NOS, the empirical NOS, and the subjective NOS at the end of the program, none of them was able to develop an informed view of any aspect. The researchers concluded that maybe with a longer program or with the use of different explicit strategies students will be able to develop informed understandings of NOS.

In Turkey, Kılıç, Sungur, Çakıroğlu, and Tekkaya (2005) examined 9th grade students' understanding of the nature of scientific knowledge with a sample of 575 students. The effects of gender and school type were also investigated. The researchers adapted the Nature of Scientific Knowledge Scale (NSKS), developed by Rubba and Andersen (1978), into Turkish. The NSKS is a 48-item Likert-type scale designed to measure participants' understanding of the amoral, creative, developmental, parsimonious, testable and unified characteristics of the scientific knowledge. The results of the study revealed that students did not realize that scientific knowledge tends toward simplicity (parsimonius), and subject to change (developmental). On the other hand, students appreciated the creative, testable and unified characteristics of the scientific knowledge. In general, the students had a moderate level of understanding of the scientific knowledge.

A more recent study conducted by Doğan (2011) in Turkey investigated and compared the NOS understandings of 11th grade students from science-math (SM) and literature-math (LM) branches. Data were collected from 120 students (60 from each branch) through the Turkish version of the POSE questionnaire (Abd-El-Khalick, 2002). In data analysis, students were categorized as naïve, uncategorized or informed for six NOS aspects: creativity, tentativeness, empirical, scientific theories and laws, observation and inference, and social and cultural embeddedness. The results of the study showed that SM students held more naïve views than LM students about creativity and social and cultural embeddedness aspects of NOS. Moreover, whereas all LM students held informed views of tentative NOS, 15% of SM students held naïve views. On the other hand, SM students held more informed views about observation and inference, and empirical aspects of NOS. None of the students were found to be having informed views about scientific theories and laws.

In conclusion, even though gaining students NOS understanding has been an ultimate objective of science education, most of the studies from all around the world consistently showed that the students with different grade levels do not have informed understandings about NOS and this disappointing conclusion could be thought to be significant as the used instruments to assess NOS varied a lot, but the results did not (Lederman, 2007).

2.1.3. Teachers' Understanding of Nature of Science

Teachers are always considered as being responsible for educating our next generation and it is generally assumed that they cannot teach something if they do not understand it (Shulman, 1987). For this reason, several attempts have been made with different studies to investigate teachers’ understanding of NOS, the ways of improving their understanding and the relationship between teachers’ understanding of NOS and their classroom practice.

Lederman (2007) identified the first attempt to assess teachers' understandings of NOS as the study of Anderson (1950). In this study, 58 biology and 55 chemistry teachers were surveyed about scientific method and the results showed that both groups of the teachers held serious misunderstandings. In the following years, the number of these studies has increased rapidly, however, since it is difficult to reach teachers studying in schools and pre-service teachers are preferred to study with, there are a limited number of studies conducted with teachers.

In earlier years of the NOS research, Behnke (1961) compared scientists and science teachers with the help of a 50-statement questionnaire to assess participants' views of the nature of science, science and society, the scientist and society, and the teaching of science. Regarding views of nature of science, it was found that over 50% of the teachers and 20% of the scientists thought that scientific knowledge was not tentative. In another study, Miller (1963) conducted a study with student groups and teachers with the help of the Test of Understanding Science (TOUS) which is designed to assess participants' understanding about the scientific enterprise, the scientist, and the methods and aims of science. The results revealed that high school student groups performed better than their teachers on the TOUS. Although the students' scores were also found to be low and their views were labeled as inadequate, % 11 of them achieved higher scores than the % 25 of the teachers. Similar results were found in the studies of Carey and Stauss (1970), Aguirre, Haggerty, and Linder (1990), and Pomeroy (1993). Abd-El-Khalick and BouJaoude (1997) also had consistent findings supporting that science teachers do not possess an adequate understanding of NOS.

Unfortunately, recent studies still revealed that science teachers do not have a contemporary understanding of NOS. In Turkey, Doğan and Abd-El-Khalick (2008) conducted a study and found similar results. 378 science teachers from different regions with different ages, backgrounds, and graduate degrees participated in the study. The researchers used fourteen modified items of the Views on Science-

Technology-Society (VOSTS) (Aikenhead & Ryan, 1992) to assess their ideas about NOS aspects and they found that most of the teachers held naïve understandings of NOS even if some of them had master and doctorate degrees; surprisingly the teachers with graduate degrees held more naïve understandings than the teachers with BS degrees. For example, majority of the participant teachers believed that different forms of scientific knowledge (hypotheses, theories, and laws) were hierarchically interrelated. Moreover, most of them held informed views about tentative nature of science but at the same time they believed that scientific laws can be "proven" to be true.

Besides the studies investigating teachers' views of NOS, there are also studies trying to enhance the development of more informed NOS views. For example, Morrison, Raab and Ingram (2009) designed a professional development experience to investigate how elementary and secondary science teachers' views of NOS and scientists influenced by explicit-reflective instruction on NOS and being in a research environment where they can actually meet with scientists, talk to them, discuss with them and observe them directly at Laser Interferometer Gravitational-Wave Observatory (LIGO). The program lasted two weeks for two summers and a total of twenty teachers attended to the program for two years. Data were collected through the VNOS-B (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002) administered as pre- and post-test, interviews conducted after the program, written work of participants generated during the summer course, audio-taped class discussions, presentation of the science activity prepared by teachers at the end of the summer course, and the notes of researchers. Analysis of the data revealed that teachers generally improved their NOS views and become able to apply the characteristics of science at the end of the program. It also seemed that NOS instructions, observations of the research facility, talking to the scientists about NOS, observing them while they were working and physically being in a research facility rather than in a classroom were identified as important factors that helped teachers in strengthening their views of NOS.

Similarly, in Turkey Doğan, Çakıroğlu, Çavuş, Bilican, and Arslan (2011) investigated the effectiveness of a one-week in-service program designed for improving elementary science teachers' views of NOS. Data were collected from 44 elementary science teachers through VOSTS questionnaires. The results of the study revealed that science teachers' improved their views about nature of scientific observations, classification schemes of scientific knowledge, scientific method, and epistemological status of hypotheses. Moreover, the teachers held contemporary views about tentativeness, nature of scientific models, and certainty and ambiguity probabilities in development of scientific knowledge, and they preserved these views throughout the program. On the other hand, the teachers held naïve views about assumptions underlying theories and laws, nature of scientific theories, epistemological status of scientific laws, coherence of scientific concepts across disciplines and scientific approach to investigations at the beginning and they did not improve them at the end of the program.

Another line of research related to teachers' understanding of NOS was tried to investigate whether teachers' NOS understanding influences their classroom practices or not. For example, Lederman (1999) investigated the relationship between teachers' understanding of NOS and classroom practice. A multiple case study method was followed with the participation of five high school biology teachers. Data were collected through classroom observations, open-ended questionnaires, interviews with teachers and students, instructional plans and materials during one full academic year. These various sources of data were analyzed independently by using analytical induction. The results revealed that all teachers had adequate understanding of various NOS aspects including tentativeness, creativity, subjectivity, empirical-basis, observation and inferences, theories and laws, and social and cultural embeddedness. When instructional practices were investigated, it was seen that there is a significant difference between experienced and beginning teachers; experienced teachers exhibited classroom practices consistent with their views of NOS and including many inquiry-based activities. However, the interviews with students showed that none of the students held adequate understanding of NOS. Therefore, the researchers concluded that teachers' understandings of NOS did not directly influence students' NOS understanding.

In their three years longitudinal study, Hanuscin, Lee, and Akerson (2011) not only tried to improve and describe teachers' understanding of NOS but also tried to characterize their pedagogical content knowledge for NOS. The participants of the study were three out of six teachers from a primary school attending a professional development program (The Inquiry Teacher Study Group) designed to improve teachers' understanding of NOS and scientific inquiry, and their NOS teaching in a way that fosters students' understanding of NOS and scientific inquiry. The program included workshops, inquiry-based activities, model lessons, providing feedbacks to teachers about their instruction and similar activities spread to three years. Data were collected through a lot of different sources including questionnaires, interviews, field notes, transcripts, videos, lesson plans, artifacts, teachers' written contributions, and a focus-group session. Findings of the study revealed that teachers were able to use effective explicit-reflective instructional strategies to teach NOS, but they did not evaluate the success of their instructions on their students' NOS understandings. The researchers assessed their students’ understandings of NOS and found that students improved their views of NOS; however, the teachers did not have required knowledge and skills to assess their students' NOS understandings on their own.

In conclusion, most of the studies conducted with science teachers revealed that they do not possess contemporary understandings of NOS; much should be done to help them to improve their NOS views. Moreover, it was seen that although teachers held adequate conceptions of NOS, they also need to know how to teach NOS. By this way students' chance to have an effective NOS instruction and gain a meaningful understanding of NOS can be increased.

2.1.4. Pre-service Teachers' Understanding of Nature of Science

Pre-service teachers are our future's teachers; therefore, providing them an effective education has been very important and focus of lots of studies in science education. Since both pre-service teacher education and nature of science understanding are very crucial topics, the number of studies related to NOS understanding of pre-service science teachers has been increasing rapidly.

In earlier years, Bloom (1989) investigated pre-service elementary teachers' understanding of science with a sample of 80 pre-service elementary teachers in three sections of an elementary science methods courses. A questionnaire composed of six questions about knowledge of science, theories and evolution, and a 21-item rating scale related to various aspects of science and science teaching were used. The results showed that most of the PSTs believed that science is a human-centered process and scientific theories reflect the scientists' personal opinions rather than evidence. Moreover, it was also found that pre-service teachers' beliefs affected their conceptualizations of science. Similarly, Meichtry (1995) investigated the effectiveness of a course including learning cycle lessons, interviews with elementary students, experiments, and inquiry lessons on PSTs' understanding of NOS. The results revealed that prior to the instruction PSTs generally held naïve understandings of NOS; however, their views improved after the course.

In Turkey, Macaroğlu, Taşar and Çataloğlu (1998) examined the Turkish pre-service elementary teachers' understanding of NOS. A total of 21 volunteer PSTs participated in the study by completing a questionnaire composed of two parts: first part included five open-ended questions (Lunetta & Koul, 1996) to measure PSTs' ability to incorporate NOS in their teaching and second part was composed of a five scale likert type questionnaire with 10 items which is a part of the Beliefs About Science and School Science Questionnaire (Aldridge, Taylor & Chen, 1997). The results showed that most of the PSTs believed that science is a completely objective process but it is also tentative.

More recently, Abd-El-Khalick (2005) examined the effectiveness of a philosophy of science (POS) course on NOS understandings of preservice secondary science teachers. The participants of the study were 56 PSTs enrolled in a science methods course for two semesters including explicit-reflective NOS instruction. 10 of them also participated in a POS course during the second semester. Data were collected through the VNOS-C questionnaires administered at beginning and end of the science methods course. In order to investigate the effectiveness of the POS course participants' lesson plans and NOS specific reflection papers were used. The results of the study showed that although science methods course was also effective in improving PSTs' understanding of NOS, the POS course was better helped them to develop deeper understandings of NOS.

In a similar study, Akerson, Morrison, McDuffe (2006) investigated the NOS understandings of 19 pre-service teachers within a science methods course in which an explicit-reflective instruction was implemented. The VNOS-B questionnaire (Lederman, Abd-El-Khalick, Bell, Schwartz, & Akerson, 2002) administered and interviews were conducted with the participants prior to the instruction and also at the end of the course. It was found that at the beginning most of the students held naïve understandings of the tentativeness, creativity, subjectivity, empirical-basis, social and cultural embeddedness, theories and laws, and observation and inferences aspects of NOS, but after explicit-reflective instruction, they had gain a much better understanding. The researchers also administered the VNOS-B again, 5 months later, to see whether students pursue that better understanding, unfortunately they found that some of the students reverted back to their earlier understanding of NOS.

In his study, Irez (2006) investigated NOS understanding of 15 prospective science teacher educators from England and United States, conducting doctorate level studies in the field education, with a reflection-oriented qualitative approach. All of the participants got their first degrees from different departments (e.g. agricultural engineering, physics, chemistry etc.) from universities in Turkey. Participants' current field of the study also varied between physics, chemistry and biology education. Data were collected through interviews that were conducted by using the questions of the Views of Nature of Science Questionnaire (VNOS-C) developed by Lederman, Abd-El-Khalick, Bell, and Schwartz (2002). The analysis of the interviews revealed that most of the participants had naïve understanding of NOS, especially about the aspects of tentativeness, lack of a universal scientific method, and the differences between theories and laws.

In a similar study with a larger sample, Erdoğan, Çakıroğlu, and Tekkaya (2006) examined Turkish PSTs' views of NOS by using VOSTS questionnaire. 166 fourth year students from elementary science education department were participated in the study. The analysis of the data showed that participants generally held a contemporary view of tentativeness of scientific knowledge and the nature of classification schemes. However, they held naïve views of the properties of hypotheses, theories and laws, the fundamental assumptions for all science, the definition of science, the epistemological status of scientific knowledge, the scientific approach in investigations, the nature of scientific models, and the paradigm versus coherence of concepts across disciplines. Moreover, most of them believed that scientific models are exact copies of reality, scientists have prior assumptions before starting to work and they try to prove them true, there is a hierarchical relationship between theories and laws, and there is a universal scientific method.

In their action research, Seung, Bryan and Butler (2009) not only investigated the preservice science teachers understandings of NOS but also examined the influence of three different explicit approaches; not context-based, context-based and content-based. Data were collected through semi-structured interviews, written artifacts and an open-ended questionnaire prepared to assess participants' views of empirical, inferential, subjective, and tentative nature of scientific knowledge, the role of creativity and social and cultural influences in science, and the development of scientific knowledge. Pre-intervention NOS views of the participants were found to be generally naïve except tentativeness and subjectivity aspects. After the intervention, most of the participants developed their views to partially informed and informed about most of the aspects. The researchers also investigated how PSTs perceived that the activities following different instructional approaches affected their NOS understanding. It was seemed that the participants perceived that each activity helped them to learn various NOS aspects and prepared them for future teaching. As a result, the researchers concluded that various approaches of teaching NOS may help preservice teachers to develop a better understanding of NOS.

A similar study was conducted by Bell et al. (2011). The researchers compared the effectiveness of different instructional approaches (implicit vs. explicit) and also the context of NOS instruction (contextual vs. noncontextual). A total of 75 PSTs enrolled in four sections of an elementary science methods course were the participants of the study. One section received explicit instruction for NOS and global climate change/global warming (GCC/GW); one section received explicit instruction for NOS but not for GCC/GW; one section received explicit instruction for GCC/GW, but not for NOS; and the control group did not receive any explicit instruction. Data were collected through pre- and post questionnaires related to NOS and GCC/GW, interviews, course assignments, and electronic journal entries during the entire semester. The comparison of the pre- and post-test showed that participants' NOS views were significantly developed when it was explicitly addressed. None of the participants improved their views of NOS aspects implicitly. Regardless of whether NOS instruction was integrated to the socioscientific issue of GCC/GW or not, when it was addressed explicitly participants made significant gains in their understanding of the NOS aspects.

In general, most of the studies trying to improve pre-service science teachers' NOS views were focused on the influence of explicit-reflective instruction. McDonald (2010) enhanced this explicit NOS instruction with argumentation instruction. The participants of the study were five preservice primary teachers enrolled in a science content course and wish to specialize in science teaching. Classes were held three hours a week for 11 weeks and included a theory section and inquiry-based section. The researcher embedded six course components to these sections which are; explicit NOS instruction, explicit argumentation instruction, argumentation scenarios, global warming task, superconductors survey (Ryder, & Leach, 2000), and laboratory project. The VNOS-C questionnaire (Lederman, Abd-El-Khalick, Bell, Schwartz, & Akerson, 2002), the global warming survey, the superconductors survey, initial and final interviews, audio-taped and video-taped class sessions, and written artifacts were used as data sources. Analysis of these various data revealed that prior to the intervention all of the participants held naïve views of the majority of NOS aspects; however, at the end four of the five participants expressed partially informed and informed views about most of the aspects. The researcher concluded that integrating explicit argumentation and NOS instruction, enriched with scientific and socioscientific contexts for argumentation, resulted in positive changes in learners' NOS views.

In addition to the studies investigating the influence of different techniques on NOS understanding of PSTs, a recent study conducted in Turkey by Mıhladız and Doğan (2012) compared pre-service science teachers and elementary science teachers in terms of their knowledge of NOS. Data were collected from 89 PSTs and 64 elementary science teachers through an adapted version of the VOSTS questionnaire (Aikenhead & Ryan, 1992). Participants' responses to the VOSTS items were categorized as naïve, has merit and realist. The results of the study showed that majority of the participant PSTs and science teachers held realistic views about tentativeness of scientific knowledge, mistakes made during the scientific investigations, definition of scientific knowledge, influence of society on scientists, and nature of classification system. On the other hand, most of them held naïve views about scientific theories and laws, and scientific models. The researchers concluded that although the PSTs and science teachers held realistic views about some aspects, they also had some naïve ideas; therefore, none of the groups could be accepted to have contemporary and informed views of NOS and they need further education about NOS.

To sum up, not only descriptive studies but also pre-test results of intervention studies consistently showed that, similar to students and teachers, most of the pre-service science teachers also held naïve understanding of NOS (e.g. Abd-El-Khalick & BouJaude's, 1997; Abd-El-Khalick & Lederman, 2000; Aguirre, Haggerty, & Linder, 1990; among others). However, as the results of the most of the experimental studies investigating the effectiveness of different instructional techniques revealed, there are ways to improve PSTs' understanding of NOS and prepare them for their future teaching.

2.1.5. Nature of Science and Personal Characteristics

Besides the studies investigating NOS understanding or the effect of different types of instructions/activities/courses/programs on NOS understanding, there are also studies focused on other factors that might be related to NOS understanding such as academic variables, gender, science background, epistemological beliefs, level of motivation, self-efficacy, worldview, metacognitive awareness have increased rapidly which had also been an inspiration for the present study.

In their case study, Schwartz and Lederman (2002) investigated the knowledge, intentions and instructional practices of two beginning secondary science teachers and compared them as they learned and attempted to teach NOS during their teaching experience and during their first year of full-time teaching. Data were collected through lesson plans, classroom observations, the VNOS-C questionnaires

(Lederman, Abd-El-Khalick, Bell, Schwartz, & Akerson, 2002) and interviews. The results of the study showed that level of NOS understanding, subject-matter knowledge and perceived relationship between them affected participants' learning and teaching NOS. The participant with more informed understanding of NOS and scientific content was better to integrate NOS in his/her teaching. On the other hand, the other participant with more naïve understanding of NOS and limited subject-matter knowledge had not been able to address related NOS topics in his/her science content.

In another study, Abd El-Khalick and Akerson (2004) examined the factors influencing the effectiveness of an-explicit-reflective NOS instruction on the development of more informed NOS views. A focus group composed of six female students enrolled in an elementary science methods course was selected for the study. The VNOS-B questionnaire (Lederman, Abd-El-Khalick, Bell, Schwartz, & Akerson, 2002), reaction papers, interviews, contributions to classroom discussions, and other course assignments were used as data sources. All participants held naïve views about nearly all NOS aspects at the beginning of the course. Three factors affecting participants’ development of NOS views were found through careful analysis of the various qualitative data: (1) internalizing the importance of NOS, (2) interaction of NOS instruction with global worldviews and (3) deep versus surface orientation to learning. Internalizing the importance of NOS was a motivational factor related to how much value the participants give to teaching and learning NOS. It was found that participants who internalized the importance of teaching NOS in their future classrooms and had concerns related to being prepared to teach NOS developed more informed NOS views. Interaction of NOS instruction with global worldviews was a factor related to participants' religious views. Participants who did not see science and religion contradictory to each other were able to abandon their naïve NOS views and develop more informed ones even though they also had religious beliefs. Deep versus surface orientation to learning was a cognitive factor related to participants learning skills. Participants with a deep process orientation to learning seek for an alternative framework immediately after they felt dissatisfaction with their present views. It was found that deep learner participants developed more informed views whereas the other participants showed little changes in their naïve NOS views.

Another study related to factors affecting learners' NOS understanding was conducted by Southerland et al. (2006). The researchers investigated how conceptual ecologies of in-service teachers influenced their views of NOS. Data were collected from five participants enrolled in a graduate course focused on NOS through questionnaires, interviews, course assignments and observations of classroom sessions. Past science experiences, affect toward science, self-efficacy, learning dispositions and related general epistemological beliefs, beliefs about learning and learners, conceptions of science as an enterprise and religious beliefs were identified as components of conceptual ecologies of participants at the beginning of the study. Based on the data analysis and comparison of the participants, the researchers concluded that past science experiences, goals for learning, emotions regarding science play a role in their conceptual ecologies meditated through learning dispositions; however, they did not find any effect of religious beliefs on participants' conceptualization of NOS. Similarly, Deniz (2007) investigated whether prior nature of science views, metacognitive awareness, thinking dispositions, science self-efficacy beliefs, and motivation of learners were related to their NOS views and their epistemological beliefs about science. However, he did not found any significant relationship between any of the variables except that PSTs' thinking dispositions were found to be related to PSTs' epistemological beliefs about science.

In their comprehensive study, Akerson and Donnelly (2008) investigated the relationship between pre-service teachers' NOS understanding and their other learner characteristics: metacognitive awareness, self-efficacy, Perry’s intellectual and ethical developmental levels, concerns for teaching NOS, and cultural values. A total of 21 master's level elementary pre-service teachers in a transition to teaching program participated in the study. The data were collected through different questionnaires and interviews at the beginning of the program. Participants' understanding of NOS aspects were classified as "informed (indicating a fully developed understanding of the NOS or inquiry aspect), adequate (indicating a developing view), or inadequate (indicating a misconception was held by the student)", then, they were compared in terms of other learner characteristics. The results showed that PSTs differed in their NOS understanding with respect to their cultural values and knowledge of cognition. There were not any significant differences between self-efficacy beliefs, regulation of cognition, developmental levels and concerns for teaching NOS of PSTs with different levels of understanding of the NOS aspects. Participants' attitudes towards science teaching was also measured but since it did not meet the statistical assumptions, any analysis could not be conducted regarding it is relationship with NOS understanding, therefore, no conclusion was driven. In a similar study conducted with pre-service early childhood teachers, Akerson, Buzzelli and Donnelly (2010) explored whether concerns about teaching NOS and intellectual levels influenced how PSTs taught NOS at the preschool and primary levels. They used videotaped classroom observations, lesson plans and questionnaires as data sources and found that how PSTs taught NOS was related to neither their concerns about teaching NOS nor their intellectual levels.

In conclusion, besides the effectiveness of NOS instruction, participants' individual characteristics may affect their development of informed NOS views. The studies investigating these factors have been increasing in recent years; however, since there are few studies related to these factors, most of the studies were explanatory in nature focused on identifying these features instead of what might be done to control these factors to enhance effectiveness of NOS instruction. The present study also tries to explain any possible connection between different characteristics of learners and their understanding of NOS to provide a framework for future studies.

2.2. Scientific Inquiry

Scientific inquiry (SI) refers to "the characteristics of the processes through which scientific knowledge is developed, including the conventions of development, acceptance, and utility of scientific knowledge" (Schwartz, Lederman, & Lederman, 2008, p. 3). According to the National Science Education Standards knowing how scientists work, identifying and developing questions, planning and conducting investigations, analyzing data and evidence, using models and explanations, and communicating findings of the investigations are the abilities required to do scientific inquiry which is another important component of scientific literacy (NRC, 1996). Moreover, researchers emphasize that doing scientific inquiry and understanding its nature is an important step for being able to understand the nature of science (Bell, Blair, Crawford, & Lederman, 2003); both implicit and explicit approach suggest the use of inquiry-based activities to enhance NOS understanding (Schwartz, Lederman & Crawford, 2004).

Schwartz et al. (2008) suggested that the importance of doing inquiry in science education strongly emphasized; however, learners' understanding of scientific inquiry and its characteristics seems to be included in a general title with NOS; understanding of science. In their study, they distinguished nature of scientific inquiry (NOSI) and nature of science (NOS) as "NOS aspects are those that pertain most to the product of inquiry, the scientific knowledge whereas NOSI aspects are those that pertain most to the processes of inquiry, the “how” the knowledge is generated and accepted" (Schwartz, Lederman, & Lederman, 2008, p.3). Moreover, in order to assess learners' understanding of NOSI aspects, they developed the Views of Scientific Inquiry (VOSI) questionnaire by revising and developing prior version of VOSI developed by Schwartz, Lederman, and Thompson (2001). Based on the previous literature, they identified seven NOSI aspects as:

1. Scientific questions guide investigations: All scientific investigations do not start with a formal hypothesis in mind; before hypothesizing scientists must ask questions.
2. Multiple methods of scientific investigations: There is no single scientific method to follow in scientific investigations. Experimental method seems to be considered as scientific method; however, not all scientific investigations require a hypothesis testing through controlling and manipulating variables. The method of a particular investigation changes according to question to be answered, the scientist, the scientific discipline and so on.
3. Multiple purposes of scientific investigations: Scientists' questions to be answered may come from different sources and serve multiple purposes. Curiosity, social influences, desire to help people, economical reasons and many other reasons may affect scientists' choice of a question.
4. Justification of scientific knowledge: Scientific claims should be justified. Consistent results, statistical or theoretical support, evidences, addressing of alternatives are the elements to justify a scientific claim. Moreover, different scientists may ask similar questions but use different methods or interpret the same data from a different perspective and come up with different conclusions with acceptable justification.
5. Recognition and handling of anomalous data: Scientists have expectations before they make an investigation; however, the results do not always fit expectations. How scientists handle these anomalies is a critical step; there may be ignorance of anomalies, negation of anomalies, inclusion without any explanation, abeyance, reinterpretation, acceptance and change of the existing theory.
6. Distinctions between data and evidence: Data and evidence are different terms with different sources and purposes. Data can take various forms and gathered during the investigation. Evidence is the product of data

analysis and interpretation of data and used to support the claim. Data analysis and interpretation is based on the question to be answered.

7. Community of practice: Community of science is composed of multiple communities in which scientific inquiry is embedded. These communities establish the standards and practices of development and acceptance of scientific knowledge. Scientists interact with each other and science is affected by this interaction, communication between scientists and peer review.

One of the studies related to improving PSTs' understanding of NOS and SI was conducted by Gess-Newsome (2002) during a 3-quarter, senior year, cohort-based elementary certification program. Data were collected from 30 participants through their responses to journal questions in order to investigate the effectiveness of the explicit-reflective NOS and SI instruction on learners' views of science. Participants responses were categorized as: "*Product* views defined science as a body of knowledge. *Process* views described science as a method of gaining knowledge. *Blended* views contained aspects of both the process and product orientations. Answers that were vague and therefore defied categorization were listed as *Unclear*, and missing data were listed in the *No answer* category." (Gess-Newsome, 2002, p. 62). The results of the study revealed that explicit-reflective instruction was effective in changing participants' views from product or process views to blended views.

A major study related to scientific inquiry and nature of science is "Project ICAN: Inquiry, Context, and Nature of Science"; a project designed to improve middle and high school science teachers' abilities to enhance students' understanding of NOS and scientific inquiry (SI) within a context of a standards-based science curriculum (Lederman et al., 2003). In the second year of the project 50 science teachers participated in the project composed of three phases: (1) 10 full-day monthly workshops during the academic year in which teachers actively participated in NOS and SI activities, discuss each other's video-taped lessons and engaged in research experiences; (2) two-week summer institute activities focused on development of performance-based assessments for NOS and SI during which teachers attended 10, six-hour sessions focused on NOS, SI, and unified concepts through explicit/reflective activities, readings, and discussions, group discussions of research experiences and classroom activities, and (3) a follow-up for which teachers videotaped at least one lesson per month, provided lesson plans, reflections, and student work for review and feedback of project staff. The VNOS-D (Lederman, & Khishfe, 2002) and the VOSI questionnaires (Schwartz, Lederman, & Thompson, 2001), journal reflections, curricular materials, video-taped lessons, lesson plans, instructional materials/assessments, and classroom observations were used as data sources to assess teachers' and students' understanding of NOS and SI and classroom applications of NOS and SI. The results of the project showed that all of the teachers developed more informed views of NOS and SI and showed improvement in their abilities to explicitly teach them within the context of their subject matter. It was also found that changing teachers’ views was not sufficient to change students' views; their classroom practices are the key. Moreover, the nature of the subject matter and the grade level had a critical role in the ease of integration of NOS and SI into classroom practices. The researchers concluded that explicit instruction and continuous support to teachers are required to improve students' understanding of NOS and SI.

In another study related to PSTs' understanding of NOS and SI concepts, Schwartz (2007) investigated the effectiveness of explicit-reflective NOS instruction embedded throughout an undergraduate biology course on developing NOS and SI views. Participants of the study were 30 students enrolled in elementary education major attending a biology course for 15 weeks. Tentativeness, subjectivity, observation and inference, creativity, theory and law, empirical-basis aspects of NOS; multiple scientific methods, scientific models, and the role of evidence in supporting explanations aspects of NOSI were explicitly addressed throughout the course by goals and objectives for NOS and NOSI, instruction, discussions, questions, individual reflections, group sharing and assessments. The VNOS (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002) and the VOSI (Schwartz, Lederman, & Thompson, 2000) questionnaires were used as primary data sources and journal entries, quizzes, and exam responses were used as secondary data sources. Based on the data analysis, participants' views were classified according to a continuum: naïve (-), emerging [(+)], informed (+), between informed and more informed (++), more informed (+++). The results showed that for all of the aspects participants' pre-test profiles were closed to naïve views; however, post-test results showed positive gains in all of the aspects. For example, in the beginning twenty out of thirty participants held naïve conceptions of tentativeness (e.g. Laws are proven to be true) and only three of them held informed views; but by the end, sixteen of them held informed views (e.g. Scientific knowledge can change with new information). Similarly, in the beginning the majority of them held naïve conceptions of scientific method expressing that there is one single scientific method, however, at the end most of them expressed informed views (e.g. Scientific methods may differ based on the scientific situation). The researcher concluded that as consistent with the previous literature, explicit-reflective instruction is effective in developing learners' views of NOS and NOSI.

In conclusion, scientific inquiry had been seen as an inseparable component of NOS; however, learners' views of nature of scientific inquiry and its aspects were ignored in most of the studies; the focus was always on NOS. The present study aims to contribute in this gap by presenting information about both NOS and NOSI understandings of the same participants.

2.3. Epistemological World Views

Schraw and Olafson (2002, p. 99) defined the term epistemological world view as “a set of beliefs about knowledge and knowledge acquisition that influences the way teachers think and make important instructional decisions”. Based on their literature reviews, they categorized epistemological world views as realist, contextualist and relativist. Table 2.1. presents the summary of these three world views.

Table 2.1. A summary of three epistemological world views

Realist	Contextualist	Relativist
There is an objective body of knowledge that is best acquired through experts via transmission; Knowledge is relatively unchanging; Students are passive recipients of a pre-established knowledge base.	Knowledge has authentic applications to the context that it is learned in; Knowledge changes over time; Learners construct shared understanding in collaborative contexts in which teachers serve as facilitators.	Knowledge is subjective and highly changeable; Each learner constructs a unique knowledge base that is different but equal to other learners.

Source; Olafson, & Schraw, 2006, p. 73.

Yılmaz-Tüzün and Topçu (2008) investigated PSTs' epistemological beliefs and the relationships among their epistemological beliefs, epistemological world views, and self-efficacy beliefs with 429 participants enrolled in five large universities in three different cities of Turkey. The Schommer Epistemological Questionnaire (SEQ) (Schommer, 1990; Topçu & Yılmaz-Tüzün, 2006), the Epistemological World Views Scale (EWVS) (Schraw & Olafson, 2002; Yılmaz-Tüzün & Topçu, 2008), and the Science Teaching Efficacy Belief Instrument (STEBI-B) (Riggs & Enoch, 1990; Tekkaya, Çakıroğlu, & Özkan, 2004) were used as data collection instruments. Based on the results of the multiple regression analyses, the researchers concluded that the less PSTs believe in innate ability factor of SEQ which includes dimensions of "Cannot learn how to learn" and "Success is unrelated to hard work" the more they feel confident about their science teaching and influencing students' achievement, and relativist in their epistemological world view. Another interesting finding of the study was that PSTs held relativist world view believing in the effectiveness of student-centered teaching approaches and at the same time they believe that science will be taught best when students memorize scientific knowledge (simple knowledge dimension of SEQ).

Tsai (2002) examined the relationships among teachers’ beliefs about teaching and learning science, and the nature of science based on the interviews conducted with 37 Taiwaneses secondary physics and chemistry teachers. Teachers' beliefs in these three areas were categorized as (Tsai 2002, p. 773):

> Traditional: "Perceives teaching science as transferring knowledge from teacher to students, learning science as acquiring or ‘reproducing’ knowledge from credible sources, and scientific knowledge as correct answers or established truths."
>
> Process: "Perceives teaching science and learning science as an activity focusing the processes of science or problem-solving procedures, and scientific knowledge is viewed as facts being discovered through ‘the’ scientific method or by following codified procedures."
>
> Constructivist: "Views teaching science as helping students construct knowledge, learning science as constructing personal understanding and science as a way of knowing."

The results of the study revealed that nearly 60 % of the teachers had consistent views, among teaching science, learning science and nature of science; each belief system highly related to one another. Most of them hold traditional views in three categories. However, five of the teachers hold traditional views of teaching and learning science whereas they had process views of nature of science. Nonetheless, there were only two teachers that had totally different views of these three categories. Tsai (2002) concluded that teachers' views of teaching and learning science related to their views of nature of science; therefore, in order to change teachers' beliefs about science it may be required to change their beliefs about teaching and learning science at first.

In conclusion, there might be a possible relationship between individuals' epistemological world views and their beliefs about nature of science. However, there are limited studies related to this relationship and it can be thought as an important gap among studies related to nature of science. The present study aims to investigate this relationship with Turkish PSTs, make a contribution to this gap and provide a basis for further studies related to this issue.

2.4. Science Teaching Self-Efficacy

Self-efficacy beliefs are defined as “judgments of how well one can execute courses of action required to deal with prospective situations” (Bandura, 1982, p.122). He suggested that perceived self-efficacy determines how much effort people will make when they face with an obstacle. He identified two components of self-efficacy that affecting behavior as; individual's (1) expectancies about outcome contingencies of an action based upon prior life experiences and (2) beliefs about his/her own ability to cope; self-efficacy.

According to Bandura's theory (Bandura, 1977), there are four main sources of self-efficacy: performance accomplishments, vicarious experience, verbal persuasion, and physiological states. *Personal accomplishments* are thought to be especially influential as successful experiences increase mastery expectations whereas repeated failures decrease. In addition, once strong efficacy expectations are developed with the help of repeated successful experiences, failures' negative influences are reduced. *Vicarious experience* is the source that depends on the observations of others while performing challenging activities; people tend to think if other people can do it they might do it as well, or at least improve their performance. However, since it is based on inferences from others' experiences, it is thought to be a less dependable source of self-efficacy when compared to personal accomplishments. V*erbal persuasion* and social encouragements are hypothesized to be third source of self-efficacy. People tend to believe they can be successful at what was difficult for them in the past with suggestions. On the other hand, without any other facilitators for effective performance, verbal persuasion may lead failures and even lower one's perceived self-efficacy. The last source, *emotional arousal* is related to psychological states such as anxiety, stress, fear that might affect one's self-efficacy while dealing with threatening situations.

Self-efficacy differs from other conceptions of self (e.g. self-worth, self-esteem, self-concept) because it is specific to a particular task (Bandura, 1997; Tschannen-Moran, Woolfolk, & Hoy, 1998). For example, a person with a high self-esteem may feel inefficacious about a specific subject such as painting whereas s/he feels efficacious about another specific task such as swimming. Similarly, some teachers may feel very confident in specific subjects such as literature but they might feel fearful about mathematics; or a science teacher might feel efficacious about teaching science in the classroom but they might feel incompetent about teaching outside of the classroom, for example on a field trip (Ramey-Gassert, & Shroyer, 1992). Moreover, teachers with a high self-efficacy are more eager to use open-ended, inquiry-based, students-centered teaching methods whereas teachers with a low self-efficacy tend to use teacher-centered methods (Çakıroğlu, Çakıroğlu, & Boone, 2005).

Science teachers are thought to be one of the most important factors in increasing the quality of teaching and learning processes and outcomes (Çakıroğlu, Çapa-Aydın, & Woolfolk-Hoy, 2012). Since self-efficacy beliefs and its components (one's beliefs about own ability and outcome expectancies) have the power the affect one's behavior (Bandura, 1982), teachers' teaching self-efficacy beliefs were studied intensely from many different perspectives in the science education literature. The previous research revealed that teachers' self-efficacy beliefs are related to student outcomes such as achievement, motivation and own self-efficacy beliefs, teachers' classroom behaviors and enthusiasm for teaching (Tschannen-Moran, & Woolfolk-Hoy, 2001).

Moreover, some other studies investigated the effect of different experiences on PSTs' science teaching self-efficacy beliefs. For example, Plourde (2002) investigated the influence of a student teaching semester on PSTs' personal efficacy and outcome expectancy beliefs and found that there was not any significant increase in personal efficacy beliefs but outcome expectancies increased significantly. A similar result was found by Ginns and Tulip (1995). In addition, Huinker and Madison (1997), Morrell and Carroll (2002), Richardson and Liang (2008), Hechter (2011), and Bursal (2012) investigated the effect of inquiry-based science methods course on PSTs' self-efficacy beliefs and found that there were significant increases.

Similarly, Palmer (2011) investigated the effectiveness of an intervention which provided cognitive mastery, enactive mastery, modeling, and verbal persuasion to twelve practicing elementary teachers. The intervention lasted for 8-weeks and included a workshop phase, an observation phase, and a teaching phase. Data were collected through interviews and Science Teaching Efficacy Belief Instrument (STEBI-A) which were administered one week before, one week after and two years after the intervention. The results of the study implied that self-efficacy beliefs of teachers increased significantly after the intervention. Moreover, all types of experiences were found to be powerful in increasing self-efficacy; however, cognitive mastery was determined to be the most powerful source which teachers experienced by being taught, observing and practicing how to teach hands-on inquiry.

In Turkey, Aydın and Boz (2010) also investigated self-efficacy beliefs and sources of these beliefs of 492 pre-service science teachers from all grade levels. Data were collected through STEBI-B instrument. Moreover, semi-structured interviews were conducted with 14 of the participants in order to investigate the sources of self-efficacy. The results of the study showed that PSTs had high scores in both of the subscales "personal science teaching efficacy" and "science teaching outcome expectancy". It was also found that fourth graders had the highest mean scores in both of the subscales. The researchers concluded that they had more experience in teaching and this result in an increase in self-efficacy beliefs. However, second and third graders scored lower than the first graders even though they had more experience. This result was attributed to PSTs realization of difficulties of being a teacher. Regarding sources of self-efficacy beliefs, most of the PSTs emphasized mastery experiences as the powerful source. Some of them also mentioned vicarious experiences as an important source of self-efficacy.

In another recent study conducted in Turkey, Bayraktar (2011) investigated the impact of a primary teacher education program on pre-service teachers' science teaching efficacy beliefs and attitudes towards science. The data collected from 282 participants through the Science Teaching Self Efficacy Beliefs Instrument (STEBI-B) and Attitudes toward Science Scale developed by using various items from various different scales. The results revealed that the primary education program had a positive impact on pre-service teachers' attitudes towards science and their personal science teaching efficacy beliefs; significant differences were found between freshmen and senior students.

Besides the studies investigating the influence of different practices, Tekkaya, Çakıroğlu and Özkan (2004) investigated the relationship between pre-service teachers’ understanding of science concepts and their self-efficacy beliefs regarding science teaching. Data were collected from 299 fourth-year pre-service science teachers through a Science Concept Test and the Science Teaching Efficacy Belief Instrument which is composed of two subscales; Personal Science Teaching Efficacy and Science Teaching Outcome Expectancy (Richs & Enochs, 1990). The results showed that the number of science courses taken and the level of conceptual understanding were related to PSTs’ personal science teaching efficacy beliefs with a small effect size. However, there was not any relationship between the number of science courses taken and PSTs' science teaching outcome expectancy and the level of conceptual understanding. The researchers concluded that the level of conceptual understanding and number of science courses completed had positive effects on personal science teaching efficacy beliefs whereas neither science teaching outcome expectancy nor the level of conceptual understanding was related to the number of science courses completed.

In a similar study, Bleicher and Lindgren (2005) investigated the relationships between conceptual understanding, self-efficacy and outcome expectancy beliefs of PSTs enrolled in a in a constructivist-oriented methods class and found that participants increased in all of the variables after attending the course. Moreover, the results also revealed that there was a direct relationship between self-efficacy and conceptual learning; participants who had more self-efficacy tend to have more conceptual understanding or vice versa. However, there was no relationship between conceptual learning and outcome expectancy.

Another study, conducted by Hanson (2006), investigated the connection between teachers' science teaching self-efficacy beliefs and their definitions of science with four teachers by means of data gathered through classroom observations, interviews and questionnaires. Based on data analyses, she found no obvious connection between one's self-efficacy beliefs and understanding of NOS aspects and concluded that high levels of self-efficacy will not guarantee a better understanding of science and NOS aspects. However; as part of the same study, when she looked from the opposite direction with 13 teachers enrolled in a professional development program emphasizing NOS, it was found that a better understanding of NOS provides an increase in personal science teaching self-efficacy.

In a recent study in Turkey, Bilican and Çakıroğlu (2012) investigated the self efficacy beliefs of three PSTs for teaching NOS. Participants were interviewed before and after they attended a science teaching methods course. During this methods course in which NOS aspects were explicitly addressed, PSTs were provided mastery experiences as they prepared lesson plans in which they integrated NOS aspects into science lessons, presented these lesson plans and get feedback from their peers and instructor; and for vicarious experiences every week the instructor presented an effective NOS teaching practice. During the post-interviews, all participants expressed their confidence for teaching NOS and stated that lesson plan activity (mastery experiences) had been very helpful for them to be able to integrate NOS into their teaching. For model NOS lessons (vicarious experiences) one PST mentioned that they had not been effective in developing her confidence in teaching science; however, they helped her to understand NOS aspects clearly. Moreover, all participants had positive outcome expectancies about teaching NOS believing that NOS teaching will help their future students to develop positive attitudes towards science.

The results of the studies investigating the relationship between conceptual understanding and self-efficacy showed that there is a direct relationship between them. Therefore, it can be thought that there might be a connection between individual's science teaching self-efficacy beliefs and their understanding of NOS and scientific inquiry.

2.5. Attitudes towards Science Teaching

Petty and Cacioppo (1981, p.7) defined an attitude as “a general and enduring positive or negative feeling about some person, object, or issue”. Similarly, Jaccard, Litardo, and Wan (1999, p. 103) stated that "an attitude is traditionally viewed as how favorable or unfavorable an individual feels about performing a behavior". In the literature, the term attitude sometimes also made reference to the terms interest, motivation, belief, value and so on (Ramsden, 1998). Moreover, Tippins and

Koballa (1991) suggested that attitudes are very powerful in shaping behavior of individuals.

In earlier years, Harty, Samuel and Andersen (1991) investigated whether there were any differences between pre-service elementary teachers' understanding of nature of science, attitudes toward science and attitudes toward science teaching enrolled in three different course sequences; Science-Process-Content/Methods Field Sequence, Science Process-Methods Sequence, and Methods Sequence. A total of 71 pre-service teachers participated in the study. Data were collected through the Nature of Science Scale developed by Kimball (1967), the Shrigley Science Attitude Scale developed by Shrigley (1974) and Preservice Elementary Teacher Attitudes toward Science Teaching Scale developed by the researchers. All instruments were administered to three groups of participants at the end of their course sequences. The results revealed that the pre-service teachers in Science Process-Methods Sequence and Methods Sequence developed a significantly better understanding of NOS than the pre-service teachers in Science-Process-Content/Methods Field Sequence; however, there was not any significant differences between three groups in terms of attitudes toward science or attitudes toward science teaching. Moreover, no significant correlations were found between understanding of NOS and attitudes toward science or between attitudes toward science teaching within any of the groups.

In his study, Wenner (1993) investigated the relationship between PSTs' attitudes towards teaching science and their scientific knowledge background with 167 participants. Data were collected through survey information regarding high school and college science coursework, the General Science Test Level II (Australian Council for Educational Research, 1983), and a slightly modified version of the Science Teaching Efficacy Belief Instrument (Riggs & Enochs, 1990). He found that PSTs’ scientific knowledge level was very low and there was a negative correlation between scientific knowledge and attitudes towards teaching science; the PSTs with a stronger belief in making a difference while teaching had the lower scores in science test.

Another study related to pre-service elementary teachers' attitudes toward science and science teaching conducted by Tosun (2000). The participants of the study were thirty-six students enrolled in an integrated mathematics, science, and social studies elementary methods course. Data were collected through the Science Experience/ Achievement Questionnaire and interviews, and the students were grouped as those with a high science achievement/experience history or those with a “low” science achievement/experience history. Analysis of the data revealed that both high and low group participants showed negative attitudes toward science. On the other hand, high group expressed more confident statements regarding science teaching.

In addition, Muğaloğlu and Bayram (2010) proposed a structural model of PSTs’ NOS views to understand connections between understanding of NOS and the possible factors that might have an effect on this understanding. Based on their literature review, they identified science process skills, attitudes toward science teaching, academic achievement in pedagogical and science courses, and social, religious, economic, political, aesthetic, and theoretical values as to be factors affecting NOS understanding. Data were collected from 281 PSTs enrolled in two different universities in Turkey by means of the Science Teaching Attitudes Scale (STAS-II) (Moore & Foy, 1997; Türkmen & Bonstetter, 1999), the Allport Vernon Lindzey Study of Values test (Allport, Vernon, & Lindzey, 1960; Ardaç, Albayrak-Kaymak, & Erktin, 1994), and the Science Process Skills Test (Okey, Wise, & Burns, 1982; Geban, Aşkar, & Özkan, 1992). Using structural equation modeling methodology, the researchers came up with a final model indicating that attitudes toward science teaching, science process skills, academic achievement in pedagogical courses, religious values, and economic values explain NOS views with low predictive power. Moreover, PSTs’ attitudes towards science teaching were found to have a positive mediator effect on their NOS views. It was also found that when all other explanatory variables were held constant, a 1.0 unit increase in PSTs' attitudes toward science teaching was likely to improve their NOS views by 0.31 units.

In a recent study, Saad and BouJaoude (2012) examined the relationships between science teachers' attitudes toward science, knowledge and beliefs about inquiry, and science classroom teaching practices. Thirty-four randomly selected teachers from Beirut participated in the study. Data were collected through the Attitudes and Beliefs about the Nature of and the Teaching of Science and the Views of Science Inquiry questionnaires, and a classroom observation log entitled “How's your Inquiry quotient?”. The questionnaires were administered before the teachers were observed in their classroom twice. After detailed data analysis, each teacher's individual profile was determined and investigated. It was found that there were no consistent relationships between teacher's attitudes and beliefs, knowledge about inquiry, and classroom practices.

In conclusion, as being directly related to self-efficacy related to science teaching (Bandura, 1982) and important for shaping individuals' behavior, attitudes towards science teaching might also be identified as another important characteristic of PSTs. Kind, Jones and Barmby (2007) also suggested that positive attitudes are important for learning. Moreover, previous studies revealed that teachers' attitudes towards science influence their classroom practices and learning of science concepts (Brand, & Wilkins, 2007); therefore, attitudes might also have an impact on learning NOS or vice versa.

2.6. Metacognitive Awareness

The term metacognition was first used by Flavell in 1976 and defined as: "In any kind of cognitive transaction with the human or non-human environment, a variety of information processing activities may go on. Metacognition refers to the active monitoring and consequent regulation and orchestration of these processes in relation to the cognitive objects or data on which they bear, usually in service of some concrete goal or objective." (Flavell, 1976, p. 232). Metacognition is considered to be composed of two essential components; knowledge of cognition and regulation of cognition.

Knowledge of cognition refers to one's knowledge about cognition in general and their own cognition. Schraw and Moshman (1995) explained three kinds of metacognitive awareness included in knowledge of cognition as declarative knowledge, procedural knowledge, and conditional knowledge. *Declarative knowledge* includes individuals' knowledge about themselves as learners and factors influencing their performance. *Procedural knowledge* refers to individuals' knowledge about their procedural skills and how to do things. *Conditional knowledge* includes individuals' knowledge about when and why to apply cognitive strategies.

Regulation of cognition refers to metacognitive activities of individuals they use to regulate cognition and control their own learning and thinking and composed of three essential skills; planning, monitoring and evaluation. *Planning* includes selecting appropriate strategies, *Monitoring* refers to individuals' awareness of their own performance and comprehension, and *Evaluation* involves one's assessment of the products and processes of his/her own learning (Schraw & Moshman, 1995).

In her extensive review of metacognition literature, Lai (2011) concluded that; (1) metacognition is related to other constructs such as critical thinking (e.g. Flavell, 1979; Martinez, 2006), motivation (e.g. Cross & Paris, 1988; Ray & Smith, 2010; Whitebread et al., 2009), and metamemory (e.g. Schneider & Lockl, 2002); (2) metacognitive abilities improve with age (e.g. Hennessey, 1999; Schneider, 2008; Schraw & Moshman, 1995); (3) metacognition can be taught (e.g. Cross & Paris, 1988; Kramarski & Mevarech, 2003). Besides that there is an agreement in the literature on the importance of metacognition in improving students' thinking and learning (Ben-David, & Orion, 2012).

In Turkey, Sungur (2007) investigated the contribution of metacognition and motivational beliefs to students' performance under consequential and non-consequential test conditions with 58 college students enrolled in an elementary statistics course. The Approaches to Learning Instrument (Miller, Greene, Montalvo, Ravindran, & Nichols, 1996; Greene, Miller, Crowson, Duke, & Akey, 2004), the Self-efficacy Scale (Greene et al., 2004), the Metacognitive Awareness Inventory (MAI) (Schraw, & Dennison, 1994) and an essay-type examination were used to collect data. Four weeks before the examination, the instruments applied to the students. Then, they randomly assigned one of the two conditions in which they were either told "This test counts towards your grade" (consequential) or "This test does not count towards your grade" (non-consequential). The results of the study showed that (1) there is a significant difference between students' performances under consequential and non-consequential conditions; they performed better when the test counts towards their grade; (2) students with higher scores of regulation of cognition and mastery goal orientation performed better on the test under consequential test conditions; students tend to use strategies such as organizing, monitoring, and evaluating when they value the results of a test, (3) under non-consequential test conditions mastery goal orientation and beliefs about the utility and importance of the content or task were better predictors of students' performance; students who wanted to improve their current understanding and held more positive perceptions about the usefulness and importance of the content or task performed better.

Regarding relationship between metacognition and NOS, Abd-El-Khalick and Akerson (2009) investigated the influence of an explicit-reflective NOS instruction combined with metacognitive strategies training on preservice elementary teachers' understanding of NOS. A pretest–post-test, comparison group, quasi-experimental study design was followed during a science methods course with forty-nine pre-service elementary teachers. Both intervention and control groups received explicit-reflective NOS instruction, but only the intervention group received training in metacognitive strategies. Data were collected through the VNOS-C (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002) and the Metacognitive Awareness Inventory (MAI) (Schraw & Dennison, 1994) questionnaires. Analysis of the data revealed that after the intervention; a) participants' MAI views did not changed in control group; however, the participants in intervention group showed significant increase; b) participants' views of the empirical, tentative, theory-driven, inferential, and creative NOS were improved in both groups; c) intervention group participants achieved significantly higher gains than control group participants in all NOS aspects except the creative NOS. The researchers concluded that development of more informed understandings of NOS is related to higher levels of metacognitive awareness.

Similarly, Peters and Kitsantas (2010) examined the effectiveness of an intervention program, Embedded Metacognitive Prompts based on Nature of Science (EMPNOS), aiming to teach NOS using metacognitive prompts within an inquiry unit. A comparison and an experimental group were formed from eighty-three eighth-grade students, randomly. Data were collected through a content test, nature of science knowledge test, metacognition survey and self-regulatory efficacy survey. Moreover, interviews were also conducted with participants. The results showed that there was a significant increase in content knowledge and nature of science knowledge for the experimental group exposed to metacognitive prompts. The groups did not differ in terms of self-regulatory efficacy or metacognition; however, experimental group showed a significant increase in metacognition when pre- and post-test scores were compared.

In conclusion, the studies revealed that the development of metacognition was effective in increasing students’ understanding of content knowledge and nature of science understanding. Therefore, it can be inferred that learners’ with a high metacognitive awareness might develop a better understanding of NOS.

2.7. Faith – Worldviews

Faith development theory, developed by Fowler (1974, 1981) defined faith as how God or a Higher being is conceptualized by people and tried to explain how this conception influences their meanings, values, beliefs, and relationships with others (Fowler, & Dell, 2006). Since they have the power to shape one's character, they can also influence one's considerations about the presented information. As being one of the strongest personal values that does not possibly change, religious values/beliefs/worldviews/faith are very important in shaping character, behavior and probably learning.

In science education literature, learners' religious beliefs were generally investigated with understanding of the theory of evolution. For example, Dagher and BouJaoude (1997) found that several students do not accept the theory of evolution because of their religious beliefs. Similarly, Meadows, Doster and Jackson (2000) claimed that when religious beliefs of the learners conflict with evolution, they resist to learn about evolution. The researchers further argued that students do not fail to learn evolution, they choose not to learn about it because they think the theory of evolution is in opposition with their religious beliefs.

Regarding the influence of religious belief on learners' understanding of NOS, Roth and Alexander (1997) conducted a detailed case study with two high school students; Todd and Brent. The data sources were three formal interviews and nine reflective essays on the nature of scientific and personal knowledge, the nature of physics and views on learning science. Based on the analysis of their qualitative data, the researchers argued that when their scientific knowledge and religious beliefs contradicted with each other, students’ strong religious beliefs cause them to have difficulties in learning science and gain a meaningful understanding of NOS.

In a similar study, Haidar (1999) investigated 31 pre-service science teachers' and 224 in-service chemistry teachers' views of NOS and also attributed these views to religious beliefs of participants. The researcher developed a questionnaire composed of 22 bipolar items; at one end there was a traditional view and at the other end there was a constructivist view of five NOS aspects. These NOS aspects were scientific theories and models, the role of a scientist, scientific knowledge, scientific method, scientific laws. Participants were asked to choose their degree of their agreement on a continuum from one to seven. The results revealed participants mostly possessed traditional views about the role of a scientist, and constructivist views about scientific knowledge. For scientific theories, scientific method and scientific laws participants were neither traditional nor constructivist, they held a mixed view. The researchers suggested that traditional views were in conflict with traditional views as it suggests scientific knowledge is absolute and there is one correct way to reach information; constructivist views were more close to participants' religious views.

As part of their study investigating the factors affecting the development of more informed NOS views, Abd-El-Khalick and Akerson (2004) also found that religious beliefs influence the learners' understanding of NOS. When students' religious beliefs contradict with NOS aspects, they cannot improve their NOS views. They concluded that students should be able to differentiate religious ways from scientific ways of knowing in order to replace their naïve views with more informed ones.

In another study conducted with pre-service science teachers in Turkey, Muğaloğlu and Bayram (2010) argued that PSTs' values influence whatever they consider to be important and desirable to learn, and therefore influence their NOS understandings. They also claimed that pre-service science teachers having strong religious beliefs might feel a contradiction between religious explanations and scientific explanations of certain phenomena, such as the origin and evolution of life; therefore, they might be less eager to adopt a contemporary understanding of NOS.

Previous studies consistently showed that individuals’ religious beliefs/worldviews directly but negatively influence their understanding of NOS; therefore, it can be considered as an important personal characteristic that is related to their NOS understanding; however, there are still very few studies related to this connection.

2.8. Summary

The previous literature suggests that without any efficient instruction students, science teachers, and PSTs do not possess adequate understandings of NOS. Moreover, explicit-reflective instruction of NOS enhanced with discussions, examples from history of science, and learning activities is the most effective way to improve learners' understanding of NOS. Besides, recent studies revealed that there might be some other characteristics of learners that have a relationship with understanding of NOS. According to the previous studies understanding of NOSI, epistemological world views, science teaching self-efficacy beliefs, attitudes towards science teaching, metacognitive awareness levels and faith/worldview schemas were thought to have an association with NOS understanding. Literature suggests that NOS understanding and NOSI understanding are interrelated and enhance each other. Epistemological world views are also thought to be related to NOS understanding. Moreover, it is also claimed that higher science teaching self-efficacy beliefs, more positive attitudes towards science teaching, higher metacognitive awareness levels and more flexible faiths are associated with higher levels of NOS understanding.

CHAPTER 3

METHODOLOGY

In the method chapter, information about design of the study, population and sample, data collection, data analysis, validity, reliability, assumptions and limitations are presented.

3.1. Design of the Study

This study was designed as a case study, aiming to reveal associations and relationships between PSTs' understandings of nature of science and their understanding of nature of scientific inquiry, epistemological world views, metacognitive awareness levels, self-efficacy beliefs regarding science teaching, attitudes toward science teaching, and faith/worldview schemas. Yin (1984) defined a case study as “an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used” (p.23). Moreover, a naturalistic inquiry approach was followed in which the researcher do not implement any intervention or treatment, and do not influence the program or participants (Patton, 1987). In conclusion, this study is a descriptive and associational case study as it tried to describe the existing situation and reveal associations between variables in a spesific case group.

3.2. Population and Sample

The sample of the present study were 60 pre-service science teachers (PSTs) that were 3rd year students at elementary science education department at elementary science education department at a public university in the Marmara region. While deciding on the sample, firstly target population was defined as all PSTs who received NOS instruction in Marmara region. Unfortunately, it was not possible to reach all PSTs in Marmara region for this study and as an accessible population a public university in a large city was defined by using purposive sampling. Since the main variable to be measured is NOS understanding, the sample needed to be composed of PSTs with different levels of NOS understandings who had received NOS instruction. For this reason, a spesific university was chosen where NOS instruction was given by an instructor with an informed understanding of NOS and ability to implement explicit-reflective NOS instruction. Moreover, some studies revealed that PSTs might abandon their informed views of NOS as time goes by, therefore, it was decided to study with 3rd year students, immediately after they have taken the "Nature of Science and History of Science" course.

Before administering the questionnaires the instructor of the "Nature of Science and History of Science" course was contacted in order to gather information about the syllabus and made sure that NOS aspects were emphasized with an explicit/reflective NOS instruction. The instructor of the course was a science education researcher conducting studies related to NOS and also studied students' undersanding of NOS for Ph.D. study. Therefore, s/he can be thought to have an informed understanding of NOS. Moreover, the instructor expressed that NOS aspects were addressed explicitly during the course through discussons, activities, and examples from history of science. The course aimed at helping PSTs comprehend historical development of science, characteristics of scientific knowledge, nature of science and its aspects, characteristics of scientists, and the relationsips between science-technology-society-environment. In addition, all of the PSTs enrolled in the course prepared learning materials related to NOS aspects using the extinction of dinosaurs as a theme and wrote reflection reports after they investigated textbooks related to NOS. There were not any emphasis on NOSI aspects; however, since NOS and NOSI aspects are closely related, they might have been mentioned during discussion of NOS. More detailed information about the sample is provided in Table 3.1.

Table 3.1. General Characteristics of the Sample

	Frequency (f)	Percentage (%)
Gender		
Female	52	86.7
Male	8	13.3
Age		
20	1	1.7
21	29	48.3
22	20	33.3
23	4	6.7
24	2	3.3
25	2	3.3
26	2	3.3
CGPA		
≤ 2.00	1	1.7
2.01 - 2.50	24	40.0
2.51 - 3.00	26	43.3
3.01 - 3.50	8	13.3
3.51 - 4.00	1	1.7
Type of the Graduated High School		
Anatolian High School	18	30.0
Anatolian Teacher Training High School	10	16.7
High School	17	28.3
Other	15	25.0
Mother's Educational Level		
Primary School	21	35.0
Elementary School	10	16.7
High School	17	28.3
University	11	18.3
Grad School	1	1.7
Father's Educational Level		
Primary School	9	15.0
Elementary School	14	23.3
High School	20	33.3
University	15	25.0
Grad School	2	3.3

Table 3.1. General Characteristics of the Sample (cont'd)

# of Science Courses Taken		
10	1	1.7
12	1	1.7
13	4	6.7
14	33	55.0
15	15	25.0
16	5	8.3
17	1	1.7
# of Educational Courses Taken		
4	1	1.7
5	2	3.3
6	40	66.7
7	13	21.7
8	3	5.0
9	1	1.7
Teaching Experience		
Yes	23	38.3
No	37	61.7
Additional Nature of Science Experience		
Yes	12	20.0
No	48	80.0
Total	60	100.0

3.3. Data Collection

In this part of the method chapter, detailed information about data collection procedure and instruments are provided.

3.3.1. Data Collection Procedure

In this study, NOS understandings and six other personal characteristics (views of scientific inquiry, epistemological world views, metacognitive awareness levels, self-efficacy beliefs, attitudes toward science teaching, and faith and beliefs) of PSTs were assessed and therefore, seven different instruments (five quantitative, Likert-type and two qualitative) were used. Moreover, in order to elaborate and confirm answers of participants to open-ended questions in qualitative instruments (VNOS-C and VOSI), interviews had also been conducted with 20% of the participants after administration of the instruments. The same questions in the questionnaires were asked to the participants again and they were encouraged to elaborate their answers.

All of the instruments were distributed to the participants on the last day of the class during their class hours of the “Nature of Science and History of Science" course. The participants were informed about the purpose of the study by the researcher before distributing the instruments. Participating in the study was completely voluntarily and all participants were given ninety minutes (two class hours) to complete all of the instruments.

3.3.2. Description of Instruments

In this study, all of the data were collected by means of Personal Information Sheet (See Appendix A), The Views of Nature of Science Questionnaire Version C (VNOS-C) (See Appendix B), The Views of Scientific Inquiry Questionnaire (VOSI) (See Appendix C), The Epistemological World Views Scale (EWVS) (See Appendix D), The Science Teaching Efficacy Belief Instrument (STEBI-B) (See Appendix E), The Science Teaching Attitude Scale (STAS) (See Appendix F), The Metacognitive Awareness Inventory (MAI) (See Appendix G), and The Scale of Faith or Worldview Schemas (SFWS) (See Appendix H), which were used after getting permission from the authors. A summary of the information about the instruments is provided in Table 3.2.

Table 3.2. List of Instruments

Instrument	Subscales	Number of items	Reliability (Cronbach Alpha)		
			Original Version	Turkish Version	Present Study
VNOS-C		10	-	-	-
VOSI		8	-	-	-
EWVS		3	-	-	-

Table 3.2. List of Instruments (cont'd)

STEBI-B	PSTE	13	.89	.84	.79
	STOE	10	.76	.76	.75
STAS	-	20	.89	.83	.86
MAI	KoC	17	.88	.77	.91
	RoC	35	.88	.88	.94
SFWS	Literal	3	-	.85	.93
	Transformation	3	-	.78	.88
	Pluralism	3	-	.57	.78

The following eight sections provide detailed information about these instruments.

3.3.2.1. The Views of Nature of Science Questionnaire Version C (VNOS-C)

The Views of Nature of Science Questionnaire (VNOS-C) is a ten-item open-ended questionnaire developed by Lederman et al. (2002) to probe views of specific NOS aspects. These aspects are: (1) empirical-basis; (2) subjectivity; (3) tentativeness; (4) scientific theories and laws; (5) observation and inferences; (6) the role of creativity; (7) social and cultural embeddedness. Three forms of the VNOS questionnaire were administered to about 2000 high school students, college undergraduates and graduates, and pre-service and in-service elementary and secondary science teachers across four continents and the results of these studies and follow-up interviews have supported a high confidence level in the validity of the VNOS for assessing the NOS understandings of a wide variety of respondents and also differentiating between NOS views of experts and novices (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002).

The Turkish form of the VNOS-C used in this study was translated and adapted into Turkish by Erdoğan (2004) in a previous study. After administering the VNOS-C questionnaire to the participants to determine their understandings of NOS, follow-up interviews had also been conducted with nearly %20 of the participants, as it was suggested by the developers of the questionnaire, by using their answers to the VNOS-C questionnaire in order to establish validity of their responses to the questionnaire and give them a chance to elaborate their answers.

3.3.2.2. The Views of Scientific Inquiry Questionnaire (VOSI)

The Views of Scientific Inquiry Questionnaire (VOSI) was used to investigate PSTs' understandings of nature of scientific inquiry. There are two forms of the VOSI that can be used with PSTs: VOSI-E and VOSI-270. In this study, these two forms were combined, common questions were eliminated and the final form with eight questions was used. Although nature of science (NOS) and nature of scientific inquiry (NOSI) or science processes are often combined under a more general “students’ understandings of science, NOS aspects pertain most to the product of inquiry, the scientific knowledge whereas NOSI aspects pertain most to the processes of inquiry, the “how” the knowledge is generated and accepted. The general aspects of NOSI include: a) questions guide investigations, b) multiple methods of scientific investigations, c) multiple purposes of scientific investigations, d) justification of scientific knowledge, e) recognition and handling of anomalous data, f) sources, roles of, and distinctions between data and evidence, and g) community of practice (Schwartz, Lederman & Lederman, 2008). There are different forms of VOSI to use with different level of participants. All of the items of all the VOSI forms were examined and validated by a panel of science educators, pilot studies were conducted and necessary alterations were made on the questions based on the results and comments (Schwartz, Lederman & Lederman, 2008).

In the present study, the developers of the questionnaire was contacted and according to their suggestion two forms of the VOSI (VOSI-E & VOSI-270) were combined, common questions were excluded and an eight-item open-ended questionnaire was obtained to assess PSTs’ views of nature of scientific inquiry. Seven NOSI aspects were targeted in this questionnaire which are: a) questions guide investigations,

b) justification of scientific knowledge, c) multiple methods of scientific investigations, d) multiple purposes of scientific investigations, e) sources, roles of, and distinctions between data and evidence, f) scientific models, g) community of practice. This form was translated into Turkish by the researcher, examined by language experts, piloted with 50 PSTs from a different university, follow-up interviews were conducted and some slight alterations were made based on students' comments. Then, the Turkish version of the VOSI was administered to the participants, and after administration follow-up interviews were conducted with nearly % 20 of the participants by using their answers to the VOSI questionnaire in order to establish validity of their responses to the questionnaire and give them a chance to elaborate their answers.

3.3.2.3. The Epistemological World Views Scale (EWVS)

The Epistemological World Views Scale (EWVS), was used to determine participants' epistemological world views, developed by Schraw and Olafson (2002). The scale consists of three vignettes representing three epistemological world views (realist, contextualist and relativist) and participants rate each item (vignette) on a 5 points Likert-type scale from "strongly disagree" to "strongly agree". Olafson and Schraw (2006, p.73) summarized these three world views as:

Realist:	There is an objective body of knowledge that is best acquired through experts via transmission; knowledge is relatively unchanging; students are passive recipients of a pre-established knowledge base.
Contextualist:	Knowledge has authentic applications to the context that it is learned in; knowledge changes over time; learners construct shared understanding in collaborative contexts in which teachers serve as facilitators.

Relativist:	Knowledge is subjective and highly changeable; each learner constructs a unique knowledge base that is different but equal to other learners.

The Turkish form of the EWVS was translated and adapted into Turkish by Yılmaz-Tüzün and Topçu (2008) in a previous study.

3.3.2.4. The Science Teaching Efficacy Belief Instrument (STEBI-B)

The Science Teaching Efficacy Belief Instrument (STEBI-B) (Riggs, & Enochs, 1990) was used to measure PSTs' science teaching self-efficacy beliefs. The STEBI-B is a 23-item 5 points Likert-type scale ranging from "strongly disagree" to "strongly agree" and composed of two subscales; personal science teaching efficacy beliefs (PSTE) (13 items) and science teaching outcome expectancy (STOE) (10 items). The PSTE subscale assess participants' beliefs about their science teaching ability and the STOE subscale measures participants' beliefs about their teaching effectiveness on students' learning (Tekkaya, Çakıroğlu, & Özkan, 2004). High reliability scores were reported by the researchers for personal science teaching efficacy beliefs and science teaching outcome expectancy subscales (.89 and .76, respectively).

The STEBI-B was translated and adapted into Turkish by Tekkaya, Çakıroğlu, and Özkan (2004). The Turkish form of the scale was subjected to factor analysis and same two factors of the original form were determined. Reliability analysis of the Turkish version showed that both of the subscales (PSTE and STOE) had high reliabilities (.84 and 76. respectively). In the present study, reliability of subscales PSTE and STOE was found to be .79 and .75, respectively.

3.3.2.5. The Science Teaching Attitude Scale (STAS)

In this study, the Science Teaching Attitude Scale (STAS) (Thompson & Shringley, 1986) was used to measure PSTs' attitudes towards science teaching. The STAS is a 20-item 5 points Likert-type scale ranging from “strongly disagree” to “strongly agree” and it is stated to be a reliable (α= .89), valid instrument useful in determining attitudes toward science teaching (Thompson & Shrigley, 1986).

The STAS was translated and adapted into Turkish by Tekkaya, Çakıroğlu and Özkan (2002) and the reliability of the Turkish version of the scale was found to be .83. In the present study, reliability of the STAS was found to be .86.

3.3.2.6. The Metacognitive Awareness Inventory (MAI)

The Metacognitive Awareness Inventory (MAI) was used to assess metacognitive awareness of PSTs, which was developed by Schraw and Dennison (1994). It is a 52-item 5 points Likert-type scale ranging from “always” to “never”. It is composed of two components which are the knowledge of cognition scale (KoC) consisting of 17 items and the regulation of cognition scale (RoC) consisting of 35 items with high reliabilities (α= .88 for both of the components) (Schraw & Dennison, 1994).

The knowledge of cognition scale has three subscales: declarative knowledge, procedural knowledge, and conditional knowledge. Declarative knowledge includes one’s awareness of their abilities, strengths, and weaknesses as a learner. Procedural knowledge is about one’s knowledge about various learning strategies/procedures and how to implement them. Finally, conditional knowledge is related to one’s knowledge about when and why to use learning strategies/procedures (Schraw & Dennison, 1994; Schraw & Moshman, 1995).

The regulation of cognition scale consists of five subscales: planning, information management strategies, comprehension monitoring, debugging strategies, and evaluation. Planning involves goal setting, selection of appropriate strategies, activation of prior knowledge, and time scheduling before learning. Information management strategies concerns skills and strategies used to process information effectively. Comprehension monitoring refers to assessment of one’s understanding, performance, or strategy use. Debugging strategies involves strategies utilized to correct understanding and performance errors. Evaluation concerns examination of strategy use and performance efficiency subsequent to learning (Schraw & Dennison, 1994; Schraw & Moshman, 1995).

The MAI was translated and adapted into Turkish by Sungur and Senler (2009) and the reliabilities of the subscales of the Turkish version of the scale was found to be .75 for Knowledge of Cognition (KoC) and .89 for Regulation of Cognition (RoC). In the present study, reliability of the subscales KoC and RoC were found to be .91 and .94, respectively.

3.3.2.7. The Scale of Faith or Worldview Schemas (SFWS)

The Scale of Faith or Worldview Schemas (SFWS) was used to assess faith development of PSTs which was developed by Ok (2009). It is a 9-item 5 points Likert-type scale ranging from “strongly disagree” to “strongly agree” and composed of three sub-scales with 3-item in each; literal belief, transformation of beliefs and pluralism. Literal belief mainly involves traditional beliefs and strictly holding on them by ignoring other world views. Transformation of beliefs is concerned about change in individuals' belief over time. Lastly, pluralism is about individuals' ideas about other religions and their tendency to show respect beliefs might also be true and real at some points.

While calculating the total score for participants, their responses to the literal belief subscale were reversed, then, a total score was calculated. A high score from the scale indicated a flexible faith/worldview (pluralist) whereas a low score indicated a conservative faith/worldview (literal). The reliabilities of the literal belief, transformation of beliefs and pluralism subscales were found to be .85, .78 and .57, respectively. In the present study, reliabilities were found to be .93 for literal belief, .88 for transformation of beliefs and .78 for pluralism.

3.4. Data Analysis

Participants’ responses to the VNOS-C and VOSI questionnaires and interviews were analyzed by using the same procedure by the researcher herself and another researcher, who has a master degree on elementary science education, independently. Firstly, the researchers analyzed the data independently, then, they came together to compare their decisions. There was over 90 % consistency between the decisions of the researchers at the beginning. Then, they compared their analyses and compromised through discussion on the differences to come up with a final decision for each of the participants.

Two rubrics were formed to analyze data for both of the questionnaires. Based on these rubrics, the participants were classified as to have an inadequate (indicating participant held a misconception), adequate (indicating a developing view) and informed (indicating a fully developed view) understanding of each of the NOS aspects and NOSI aspects (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002; Akerson, Buzzeli, & Donnelly, 2010) . After assessing each participant on all of the NOS and NOSI aspects, their general NOS and NOSI views were determined by following a similar method described by Saderholm (2007), and Morrison, Raab, and Ingram (2009) to generate NOS profile of participants. Moreover, two experts from the elementary science education department of METU were consulted and their approval was taken. In this method, inadequate views were scored as 1, adequate views were scored as 2 and informed views were scored as 3 for each aspect. Then a total score was gathered ranging between 7 and 21. Participants with a total score of 10 or less were labeled as to have an inadequate view; participants with a total score between 10 and 18 were labeled as to have an adequate view and participants with a total score of 18 and more were labeled as to have an informed view.

Table 3.3. and 3.4. present the rubrics used during the analyses.

Table 3.3. Rubric for analyzing VNOS-C data.

NOS Aspect	Inadequate	Adequate	Informed
Empirical-basis	Study of the world. Just works with experimenting.	Investigation of nature. Based on experimenting and observations.	Not dogmatic. Based on evidence. Scientists have questions to be answered. The way to understand nature; how and why natural phenomena occur.
Subjectivity	Science is completely objective.	Recognition of subjectivity, but no detailed explanation.	Scientific knowledge is subjective, affected from scientists' background, way of thinking, beliefs.
Tentativeness	Scientific knowledge is absolute, proven and do not change.	Scientific knowledge may change due to technologic developments.	New information and reinterpretation of the existing information may change scientific knowledge. Current information provides a basis to future work.
Theories & Laws	Hierarchical relationship. Laws do not change, theories may change.	Both theories and laws may change, and different from each other. No example.	Detailed explanation and examples. No hierarchical relationship.
Observation & Inference	Only guess when there is no "proof". No implication of observation and inference.	Recognition of the role of observation and inference.	Detailed explanation about observation, inference and prediction and how they serve as evidence for development of scientific knowledge.
Creativity	No use of creativity.	Creativity may be used only in some parts of investigations.	Important for all parts of investigations. Detailed explanations and examples are provided.
Social & Cultural Embeddedness	Science is universal, independent from the society/culture.	Science may affect society, but society does not (or vice versa).	Science and society influence each other. Detailed explanations and examples are provided.

Table 3.4. Rubric for analyzing VOSI data.

NOSI Aspect	Inadequate	Adequate	Informed
Guide of Questions	Focus is on experimenting, ignoring questions.	Scientists ask questions, collect and analyze data.	Detailed explanation and examples about different sources of questions and importance of questions.
Justification	Scientists are never sure. Supporting data is proof.	Repeating the experiments, having consistent data.	Various types of data, different perspectives, use of previous information and other studies.
Multiple Methods	There is a single scientific method with certain steps.	No single scientific method. Scientists may create their own way to work on their problem.	Scientists' method to work on a problem may differ according to the scientific discipline, the scientist and the question to be answered.
Multiple Purposes	No meaningful explanation about purpose of scientific investigations.	Curiosity and questions on scientists' minds determine scientific investigations.	Detailed explanation and examples about factors affecting scientists’ choice of question to investigate such as their curiosity, background, society etc.
Data & Evidence	No meaningful definition of data and evidence.	Data is all of the information collected and evidence is the ones supporting the scientist's claim	Detailed explanation of the terms data and evidence. Data have various forms and evidence is the form of data after it has been analyzed and interpreted.
Scientific Models	No definition. Only an example is provided.	Embody conceptual information which is not observable through naked eyes.	Representations of the results of scientific investigations created with the help of observations, evidences and creativity. Useful for further studies.
Community of Practice	Communications between scientists do not have any effect on scientific processes.	Scientists’ interaction while doing science may affect their work.	Clear explanation about the relationships in the scientific communities. Communication affect scientists' work and how science progress.

The quantitative instruments were analyzed based on the information provided by the developers of the instruments. They were scored by totaling the responses to each item by taking into consideration the reverse items. After scoring each instrument and subscales, descriptive statistics were obtained. As inferential statistics, Chi-square Test for Independence and Kruskal-Wallis Test were performed to investigate whether there is a difference in PSTs' personal characteristics according to their Nature of Science understanding or not. Non-parametric statistics were prefered because of the small sample size in groups and having difficulties in meeting the level of measurement, normal distribution, and homogeneity of variance assumptions of parametric tests. IBM SPSS Statistics 20 program was used for all of the statistical analysis.

3.5. Validity and Reliability

For all of the instruments used in this study, validity and reliability studies have been conducted before when they were developed and adapted. They are all considered as appropriate, useful and reliable to measure intended variables.

3.5.1. Internal Validity

Internal validity of a study means that the differences obtained in the dependent variable is related to independent variable, not due to any other external variables (Fraenkel & Wallen, 2006).

Since in the present study data were collected through different questionnaires at the same time, it could be thought to be free from history (when an unexpected event occurred during the study and affected the results), maturation (passing time is the reason of the differences in the results, not the intervention), regression (differences in the results is extremely low or high), mortality (loss of subjects throughout the study), location (different locations in which data were collected may create a difference) and instrumentation (the way in which instruments were used) and implementation (a treatment may be implemented in ways that are not a part of the method) threats (Fraenkel & Wallen, 2006).

The biggest threat in this study is instrumentation. Instrument decay (the instrument and/or scoring was changed in some way) is one of the related threats, however, by using instruments for which validity and reliability studies conducted and two researchers to analyze qualitative instruments, this threat was tried to be minimized.

Another threat, data collector characteristics, was tried to be minimized as using the same data collector throughout the data collection procedure. Lastly, data collector bias threat was tried to be handled by standardizing all procedures.

Testing is the major threat for this study since seven different instruments were used at the same time. Participants' responses to one instrument might be affected by their responses to another instrument and this is a limitation of the present study.

3.5.2. External Validity

External validity is the generalizability of the findings of a research study (Fraenkel & Wallen, 2006). In the present study, since purposive sampling was used to study with a spesific group, representativeness of the sample may be doubtful. However, the results of the study might be generalized to the other groups with similar characteristics.

3.5.3 Reliability

For reliability, alpha coefficient was calculated for all of the quantitative instruments. Moreover, the design of the study, the procedures, data collection and analysis process, and the participants and the determination of these participants were clearly described for further studies.

3.6. Assumptions

1) The administration of the questionnaires took place under standard conditions.
2) All of the participants responded to the questionnaires honestly and seriously.
3) Participants did not interact with each other during the administration of the questionnaires.
4) The sample of the study was assumed to be a representation of the actual population.

3.7. Limitations

1) The results of the present study could only be generalized to other PSTs with similar characteristics to the present sample.
2) The findings of this study relied on students’ self-report responses to instruments.
3) Students' responses to one instrument might be affected from their resposes to another instrument.

CHAPTER 4

RESULTS

In the results chapter, findings of the statistical analysis are presented. There are two sections including (1) descriptive statistics and (2) inferential statistics for comparison of PSTs' views of scientific inquiry, epistemological world views, metacognitive awareness levels, self-efficacy beliefs, attitudes toward science teaching, and faith and beliefs according to their understanding of Nature of Science.

4.1. Descriptive Statistics

As descriptive statistics, frequency tables for Views of Nature of Science Questionnaire Version C (VNOS-C), Views of Scientific Inquiry Questionnaire (VOSI) and Epistemological World Views Scale are presented. For Science Teaching Efficacy Belief Instrument (STEBI-B), Science Teaching Attitude Scale (STAS), Metacognitive Awareness Inventory (MAI), and Scale of Faith or Worldview Schemas (SFWS), and all of their subscales means and standard deviations are presented.

4.1.1. Descriptive Results for Views of Nature of Science Questionnaire

Research Question 1: What are PSTs' understandings of NOS?

In this section, the frequency distribution of the inadequate, adequate and informed views of PSTs about each of the NOS aspects was presented in detail. Moreover, excerpts from PSTs responses to VNOS-C items were illustrated.

Regarding PSTs' understanding of empirically-based nature of science, majority of the PSTs (61.7%) held adequate views; stating that science is about experimenting, observing and collecting data about the world around us. About 23.3% of the PSTs held informed views; explaining in detail that science requires exploration of the nature, collecting data through experiments and observations, interpreting these data, providing evidence for scientific claims. However, 15% of the PSTs held inadequate views of empirical-basis; providing no accurate explanations and mostly believing science is just about experimenting.

When PSTs' understanding of subjective nature of science was investigated, it was seen that half of the participants held adequate views; being aware of scientific inferences and interpretations may be affected from the scientists' background, personal beliefs, and worldview. About 33.3% of the PSTs held informed views about subjectivity; providing detailed information to how scientists' personal characteristics, their way of thinking and the theories they use might influence their work. On the other hand, 16.7% of the PSTs held inadequate views; believing that science is a completely objective process.

Investigation of PSTs' views of tentative nature of science, it was seen that nearly half of them (46.7%) held adequate views; recognizing scientific knowledge might change because of technological developments and discovery of new information. About 31.7% of PSTs held informed views about tentativeness; explaining that scientific knowledge might change due to reinterpretation of old new knowledge, discovery of new information, obtaining new data on the same topic and current knowledge and theories provide a framework and basis for future investigations. However, 21.7% of PSTs held inadequate views; stating that scientific knowledge is absolute if it is proven before.

The distinction between theories and laws was not known by majority of the PSTs (68.3%); they believed that theories become laws when they are proven and after becoming a law they do not change. On the contrary, 18.3% of the PSTs held informed views; being able to define a theory and a law, providing an example to both of them and stating that they both can change but never turn into one another. Only 13.3% of the PSTs held adequate views about theories and laws; being aware of that there is no hierarchical relationship between theories and laws and they both can change.

Regarding the role of observation and inferences, nearly half of the PSTs held inadequate views (45%); believing scientists only guess something if they cannot see it with naked eye. Most of the other participants held adequate views about observation and inferences (41.7%); stating that even if scientist cannot see or observe everything directly, they may make inferences or predictions by collecting data. Only 13.3% of the PSTs held informed views about the role of observation and inferences in science; providing detailed explanations and examples about how scientists make observations and experiments to collect data, then, they make interpretations and inferences based on these evidences.

When PSTs' understanding of the role of creativity in science was investigated, it was seen that nearly half of them held adequate views (48.3%); recognizing scientists might use their creativity for some cases and for some parts of the scientific investigation if they have to. However, 26.7% of them held inadequate views; stating that scientists never use their creativity and imagination during scientific processes. On the other hand, 25% of the PSTs, close to the portion of PSTs with inadequate views, held informed views; explaining that scientists use their creativity whole the time as they collect data, interpret these data and come up with conclusions; it is a part of their work.

Regarding the social and cultural embedded nature of science, most of the PSTs held inadequate views (55%), believing that science is completely universal and not affected by society. About 26.7% of the PSTs held adequate views stating that society and culture might have an influence on science but they do not know how. Lastly, 18.3% of them held informed views about social and cultural embeddedness of science, explaining and providing examples that science is affected by the power structures, politics, philosophy, religion, socioeconomic structure of the society in which it is practiced.

Table 4.1. presents example excerpts of PSTs' inadequate, adequate and informed views of all of the target aspects of NOS.

Table 4.1. Example Excerpts from PSTs' responses to VNOS-C items

NOS Aspect	Inadequate	Adequate	Informed
Empirical-basis	"Science and religion are different, because science is human-made whereas religion is God-made. Experiments are made to invent something." (PST #37)	"Science differs from religion because scientific claims are supported by experiments and observations. Science cannot progress without experiments; scientists prove their hypothesis with experiments." (PST #2).	"Science is different from other disciplines because it is the study of nature and based on scientific data. Scientists ask questions and try to find answers to these questions with experiments and observations. Sometimes scientists make experiments sometimes they make observations and sometimes they use both of them to support their claims. Personal ideas and beliefs cannot be considered as scientific without any empirical support." (PST #8)
Subjectivity	"If two scientists used the same information but drew different conclusions, it means one of them did something wrong." (PST #19)	"Although they use the same data, since scientists have different backgrounds they may interpret it differently. Different people look at the same thing but see different things." (PST #24).	"Science is never completely objective, it is subjective. Scientists may draw different conclusions by looking at the same data because they have different background knowledge and beliefs. Moreover, they may choose different theories in the beginning and this may lead them to make different interpretations." (PST #7)
Tentativeness	"Theories cannot change if they were proven before with experiments; however, some theories may change if they cannot be proven with experiments; for example, theory of evolution." (PST #40)	"Theories can change because as technology develops more detailed experiments can be made and new data can be found; but we should learn them anyway because it makes us learn the new theories easier." (PST #34)	"Scientific knowledge and theories can change with the help of new observations and experiments. Sometimes reinterpretation of the existing theories may also result in changes. However, we should learn theories because new theories are also based on the prior theories. Science progress cumulatively." (PST #53)

Table 4.1. Example Excerpts from PSTs' responses to VNOS-C items (cont'd)

Laws & Theories	"Theories are prior steps of laws; when they are proven they become a law." (PST 22#)	"Theories and laws are different; they can both change but never become one another." (PST #44)	"Theories are scientific explanations to natural phenomena whereas laws are statements of them. Theories explain how things occur, laws state what happens. They can change but do not turn into each other. For example, theory of evolution explains how life started and developed; however, law of gravitation states the force of attraction between two masses but does not explain why they attract. " (PST #49)
Observation & Inference	"Scientists guess the things they cannot see. Sometimes they need to use their logic and senses to explain and define things." (PST #36)	"When scientists cannot see things directly they use tools to observe it. Or they make predictions and try to support these predictions with experiments. Then, based on the data they collected they make inferences. However, they can never be sure about the results." (PST #30)	"They cannot see atom directly but by using the data they collected by observations and experiments they make inferences. Similarly, they cannot go and see the solar system directly but they make observations by using scientific tools and collect data. Based on these data, they make inferences and form models for atom, solar system etc." (PST #54)
Creativity	"Scientists do not use their creativity, they use experiments. If they use their creativity and imagination, they will be changing the facts." (PST #45)	"Scientists use their creativity while deciding on what to investigate and planning their study. However, when they collect, analyze and interpret data, and draw conclusions, they only use the data they collected." (PST #21)	"Creativity can be thought as the sixth sense of the scientists. At every step of their work, they use their creativity and imagination. However, this does not mean they make up anything without any support, they combine their scientific skills with their creativity. For example, it would be impossible for Archimedes to discover the buoyancy force without using his creativity." (PST #14)

Table 4.1. Example Excerpts from PSTs' responses to VNOS-C items

Social & Cultural Embed.	"Science is universal. Science does not try to explain social and cultural values of the societies, it explains the nature and nature is the same everywhere." (PST #9)	"Scientists might be affected from the societies they live in and therefore, science might be affected. Societies' needs might also influence scientists' choice of investigation." (PST #27)	"Science reflects norms and values of societies. For example, in some societies theory of evolution is seen as inconvenient as it contradicts with their religious beliefs. So, a scientist studying evolution in this society may interpret the data with these beliefs and prior judgments in mind. As a result, social norms and personal beliefs might affect a scientists' work and conclusions." (PST #31)

Summary

Based on the analysis of PSTs' understanding on different aspects of nature of science, their general NOS profiles were determined. Inadequate views were scored as 1, adequate views were scored as 2 and informed views were scored as 3 for each of the aspect. Then, their total scores were calculated and PSTs with a total score of 10 or less were labeled as to have an inadequate view; participants with a total score between 10 and 18 were labeled as to have an adequate view and participants with a total score of 18 and more were labeled as to have an informed view. It was seen that one-third of the PSTs held inadequate understanding of nature of science (33.3%), expressing inadequate ideas about most of the aspects. Nearly half of them held adequate views about most of the aspects (45%), so their general NOS understandings were concluded to be adequate. Lastly, 21.7% of them were thought to be having an informed understanding of nature of science as they had informed and adequate views on most of the aspects. A summary of the descriptive results for PSTs' overall views of nature of science and its aspects can be seen in Table 4.2.

Table 4.2. Frequency and Percentage Values for VNOS-C Questionnaire

	Inadequate		Adequate		Informed	
	f	%	*f*	%	*f*	%
Empirical-basis	9	15.0	37	61.7	14	23.3
Subjectivity	10	16.7	30	50.0	20	33.3
Tentativeness	13	21.7	28	46.7	19	31.7
Theory & Law	41	68.3	8	13.3	11	18.3
Observation & Inference	27	45.0	25	41.7	8	13.3
Creativity	16	26.7	29	48.3	15	25.0
Social & Cultural Embeddedness	33	55.0	16	26.7	11	18.3
Overall NOS View	20	33.3	27	45.0	13	21.7

4.1.2. Descriptive Results for Views of Scientific Inquiry Questionnaire

Research Question 1: What are PSTs' understandings of NOSI?

In this section, the frequency distribution of the inadequate, adequate and informed views of PSTs about each of the NOSI aspects was presented in detail. Moreover, excerpts from PSTs responses to VOSI items were illustrated.

Regarding PSTs' understanding of how questions guide scientific investigations, nearly half of them held adequate views (45%); stating that scientists ask questions about the natural phenomena, and collect and analyze data to answer their questions. About 38.3% of the PSTs held inadequate views; only focusing on experimenting and hypothesizing. Only 16.7% of the PSTs held informed views; explaining in detail that scientists are curious about the world around us, ask questions in order to satisfy their curiosity, and all scientific investigations begin with a question to be answered.

When PSTs' views of how scientific knowledge is justified was investigated, it was seen that majority of them held adequate views (61.7%); noting that in order to think their own work as acceptable, scientists repeat the same experiments and get consistent results. 25% of the PSTs held inadequate views; just stating that if they have data to support their hypothesis, they can be thought as to have proof. On the other hand, some of them with inadequate views believed that scientists never be sure about their claims. Only 13.3% of the PSTs held informed views about justification, explaining that scientists collect various data to support their claim, look from different perspectives to the same problem and support it with previous information.

Nearly half of the participants held adequate views about multiple methods of scientific investigations (51.7%); stating that there is no single scientific method, scientists may create their own way to work on their problem. However, 35% of them held inadequate views of scientific method, believing that there is a single scientific method which should be followed by all scientists. Only 13.3% of the PSTs held informed views about scientific method, explaining in detail that scientists' method to work on a problem may differ according to the scientific discipline, the scientist and the question to be answered.

Regarding PSTs' views of multiple purposes for doing science, most of them held adequate views (48.3%); stating that scientists are curious and have questions on their minds and try to answer these questions with scientific investigations. On the other hand, 31.7% of the participants held inadequate views; providing no meaningful explanation about what scientists investigate, why do they choose that particular topic and how to they their investigations. About multiple purposes of scientific investigations, 20% of the PSTs held informed views explaining that there are different factors affecting scientists’ choice of question to investigate such as their curiosity, background, society, their desire to help the people and so on.

Investigation of PSTs' views on the sources, roles of, and distinctions between data and evidence showed that 41.7% of the PSTs held adequate views; stating that data are all of the information collected and evidences are the ones supporting the scientist's claim. On the other hand, 33.3% of them held inadequate views; not being able to define the terms data and evidence accurately and differentiate them. Only 11.7% of the PSTs held informed views; providing detailed explanation to the terms data and evidence as data can take a variety of forms, can be quantitative or qualitative, and evidence is the form of data after it has been analyzed and interpreted to answer a specific question.

When PSTs views of scientific models were investigated, it was found that nearly half of them held inadequate views (46.7%); not being able to define a scientific model, just giving an example to it such as DNA model or atom model. Close to the portion of PSTs held inadequate views, 41.7% of them held adequate views; stating that scientific models are used to embody conceptual information about a natural phenomenon which is not observable through naked eyes. Only 11.7% of PSTs held informed views of scientific models explained that scientific models are representations of the results of scientific investigations which are created with the help of observations, evidences and creativity, and useful for further investigations.

Regarding community of practice aspect, more than half of the PSTs were found to be holding adequate views (55%); stating that scientists’ interaction while doing science may affect their work. The portions of PSTs with informed and inadequate views were close to each other. About 23.3% of them held informed views; clearly explaining the relationships in the scientific communities and noting that communication between scientists may affect their work and how science progress. On the other hand, 21.7% of them held inadequate views; believing that communication between scientists does not have any effect on scientific processes.

Table 4.3. presents example excerpts of PSTs' inadequate, adequate and informed views of all of the target aspects of NOS.

Table 4.3. Example Excerpts from PSTs' responses to VOSI items

NOSI Aspect	Inadequate	Adequate	Informed
Questions Guide Investigations	"Scientists decide what to investigate according to previous studies. They have hypotheses in mind and make experiments to test them." (PST #10)	"Scientists observe and ask questions about the nature. Then, in order to answer their questions they collect data by experimenting and observing." (PST #30)	"Scientists are curious about the world. They constantly ask questions about everything that arouse their interest and all scientific investigations begin with these questions. For example, when the apple felt, Newton asked "why?" and try to answer this question." (PST #54)
Justification of Scientific Knowledge	"Scientists need to have proof to say that their work is acceptable." (PST #22)	"Scientists make the same experiments over and over again to prove their hypothesis. When they become sure about their results, their hypothesis become justified." (PST #46)	"Scientists collect data to support their hypothesis. They try to cover all angles of the problem. Moreover, they use previous studies to support their ideas. They also repeat their study and get consistent results before they share their work." (PST #8)
Multiple Methods of Scientific Investigations	"All scientists follow the scientific method, they form a hypothesis, make experiments to test it and based on the results they accept or reject their hypothesis." (PST #16)	"There is no single scientific method in science, scientists may work differently on the same problem. Sometimes while working on a hypothesis, they relalize something and change their steps; experimenting comes before hypothesizing. Scientists find their own way. (PST #46)	"Scientific method is subjective like science. Scientists have different working styles. Moreover, the described steps are only valid for experimenting; however, some studies are only based on observations. Scientists' methods vary according to their study." (PST #14)

Table 4.3. Example Excerpts from PSTs' responses to VOSI items (cont'd)

Multiple Purposes of Scientific Investigations	"Scientists make experiments to understand the world. They decide what to investigate based on their educational background." (PST #33)	"Scientists make observations and choose questions to investigate. In general, their curiosity is their driving force. By making experiments and observations they try to answer their questions." (PST #38)	"There are a lot of different factors that affect scientists' questions. For example, they may want to help society by making a medical discovery. Or they may be interested in something beginning from their childhood and they investigate it when they become a scientist. Moreover, economical factors may also affect them." (PST #57)
Sources, Roles of, and Distinctions between Data and Evidence	"Data is the results of experiments. If they are correct, they are considered as evidences." (PST #40)	"Data is the information collected by scientists during investigations. Data is different from evidence; when the data is analyzed, if they support the hypothesis, they become evidences." (PST #52)	"Data is everything that can serve as an information to answer a scientific question. For example, observations, written materials, experiment results are different kinds of data. However, not all of the data is evidence in a study. After collecting data, scientists analyze and interpret them according to their question. Then, they use these interpretations as evidences to support their claims and conclusions." (PST #49)
Scientific Models	"Scientific model is like DNA model and cell model; picture version of the written information." (PST #12)	"Scientific models are used to simplify and visualize scientific information about a concept that cannot be seen directly." (PST #31)	"Scientific models are solidified representations of scientific information. Based on their observation and experiments, and using their imagination, scientists define and explain scientific structures and systems. They cannot see them directly but try to predict their inner structure. By this way, they make them easier to understand. For example, we cannot see DNA but we can visualize its structure easily because of the DNA model created." (PST #17)

Table 4.3. Example Excerpts from PSTs' responses to VOSI items (cont'd)

Community of Practice	"If different scientists work on the same problem in the same way, they will come to the same conclusion. If they work differently, one of them can draw a wrong conclusion. However, if they work together, they will find the same thing." (PST #25)	"Although scientists work on the same problem, they may come up with different conclusions based on their method. Sometimes they may follow the same method but interpret the data differently, therefore, draw different conclusions." (PST #34)	"Scientists working on the same problem may come up with the same conclusion or not; but it is not related to their method, it is related to subjective nature of science. However, if they work together they may discuss these differences and comprise. Scientists' interaction during the investigation can affect the progress and results. (PST #7)

Summary

Based on the PSTs' assessment on different aspects of nature of scientific inquiry, their general NOSI profile were determined. Inadequate views were scored as 1, adequate views were scored as 2 and informed views were scored as 3 for each of the aspect. Then, their total scores were calculated and PSTs with a total score of 10 or less were labeled as to have an inadequate view; participants with a total score between 10 and 18 were labeled as to have an adequate view and participants with a total score of 18 and more were labeled as to have an informed view. It was seen that about 38.3% of them found to hold inadequate understanding of nature of scientific inquiry, expressing inadequate ideas about most of the aspects. Nearly half of the PSTs held adequate views about most of the aspects (48.3%), so their general NOSI understandings were concluded to be adequate. Lastly, 13.3% of them were thought to be having an informed understanding of nature of science as they had informed and adequate views on most of the aspects. A summary of the descriptive results for PSTs' overall views of nature of scientific inquiry and its aspects can be seen in Table 4.4.

Table 4.4. Frequency and Percentage Values for VOSI Questionnaire

	Inadequate		Adequate		Informed	
	f	%	*f*	%	*f*	%
Guide of Questions	23	38.3	27	45.0	10	16.7
Justification	15	25.0	37	61.7	8	13.3
Multiple Methods	21	35.0	31	51.7	8	13.3
Multiple Purposes	19	31.7	29	48.3	12	20.0
Data & Evidence	20	33.3	25	41.7	15	25.0
Scientific Models	28	46.7	25	41.7	7	11.7
Community of Practice	13	21.7	33	55.0	14	23.3
Overall NOSI View	23	38.3	29	48.3	8	13.3

4.1.3. Descriptive Results for Epistemological World Views Scale

Examination of the descriptive scores for epistemological world view scale showed that out of 60 pre-service teachers, 33 PSTs (55%) committed to contextualist and relativist world views together. This means that they both agree with the definitions that implies "Knowledge has authentic applications to the context that it is learned in; knowledge changes over time; learners construct shared understanding in collaborative contexts in which teachers serve as facilitators (Contextualist)" and "Knowledge is subjective and highly changeable; each learner constructs a unique knowledge base that is different but equal to other learners (Relativist)” (Schraw, & Olafson, 2002, p. 73).

There were not any major differences between the percentages of other PSTs indicated an agreement with a single epistemological world view. There were 9 PSTs (15%), endorsed a realist world view which is suggesting that there is an objective body of knowledge that is best acquired through experts via transmission; knowledge is relatively unchanging; students are passive recipients of a pre-established knowledge base (Schraw, & Olafson, 2002, p. 73). A total of 8 PSTs agreed with contextualist world view (13.3%) and 10 PSTs committed to relativist world view (16.7%).

Figure 1 presents a summary of the distribution of the epistemological world views among PSTs.

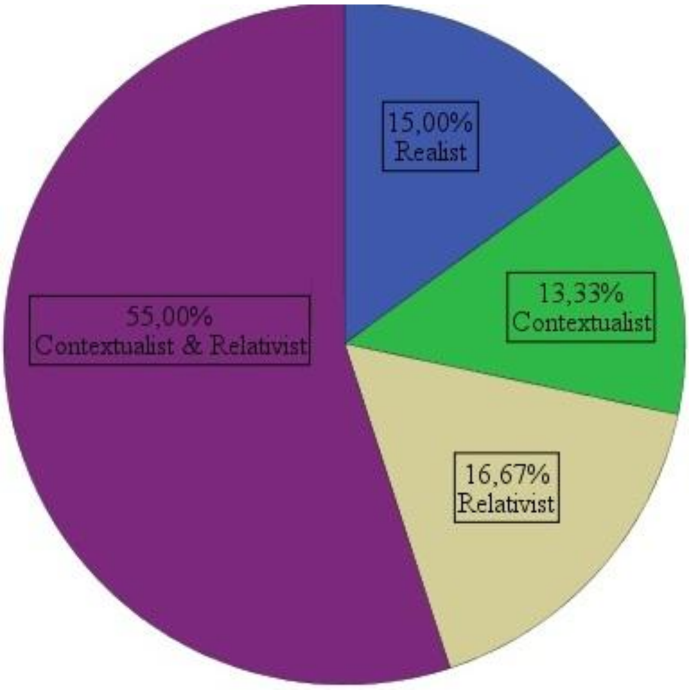

Figure 4.1. Percentages of epistemological world views among PSTs

4.1.4. Descriptive Results for Science Teaching Efficacy Belief Instrument

Examination of the descriptive results for Science Teaching Efficacy Belief Instrument (STEBI-B) and its subscales-Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE) on a five-point scale revealed that pre-service science teachers generally had high self-efficacy beliefs about their personal science teaching efficacy beliefs (M = 4.04, SD = .39) and moderate level of science teaching outcome expectancies (M=3.58, SD = .47). In general, their science teaching efficacy beliefs were found to be high (M=3.84, SD = .34).

Concerning PSTE, majority of the participants indicated a high confidence in teaching science effectively (96.6%), following science experiments made by students effectively (93.3%), finding better ways to teach science continuously (88.3%), and helping students who had difficulties in understanding the science concepts (90%). Very few PSTs felt uncertain about knowing required steps to teach science concepts (16.7%), understanding science concepts well enough to teach science (16.7%), and answering questions about science experiments (18.3%). In general, it can be concluded that PSTs felt confident in their general science teaching efficacy even though they had some minor doubts.

When PSTs' responses to STOE items were investigated, it was seen that most of them believed that with an effective instruction, students' incompetencies could be overcome (95%), students' achievement in science is directly related to teachers' effectiveness (80%) and the improvement in students' grades is a result of teachers having found a more effective teaching approach (78.3). On the other hand, some of the PSTs felt uncertain about teachers being responsible of students' low achievement in science (26.7), teachers' extra attention being the reason for improvement in children's achievement (25%), teachers' being responsible for students' achievement in science (38.3%). In general, PSTs believed that teachers' efforts would have positive effects on students' achievement; however, they had also some doubts about the influence of teacher on students.

4.1.5. Descriptive Results for Science Teaching Attitude Scale

Examination of the descriptive results for Science Teaching Attitude Scale (STAS) on a five-point scale showed that pre-service science teachers had high positive attitudes towards teaching science (M=3.93, SD = .42). When PSTs responses to STAS items were investigated, it was seen that majority of them thought that it is important to teach science concepts in elementary education (95%), they would enjoy conducting laboratory activities (95%), they do not feel anxious about teaching science (86.7%), science is as important as literacy and mathematics (98.3%) and they would integrate science to other disciplines (81.7%). Although some of them felt uncertain about students' interest towards science lesson (45%), not being able to answer students' questions (25%) and having difficult times understanding science (18.3%), their general attitudes towards science teaching could be considered to be positive.

4.1.6. Descriptive Results for Metacognitive Awareness Inventory

Examination of the descriptive results for Metacognitive Awareness Inventory (MAI), its subscales Knowledge of Cognition (KoC) and Regulation of Cognition (RoC), and their components on a five-point scale revealed that PSTs had high scores on all of the components of the KoC (M = 3.93, SD =.48) and RoC (M = 3.91, SD =.48) subscales.

Concerning KoC, majority of the participants expressed that, most of the time, they try to use strategies that have worked in the past (86.7%), they understand their intellectual strengths and weaknesses (78.3%), they are good at organizing information (83.3%), they can motivate themselves to learn (78.3%) and they use their intellectual strengths to compensate for their weaknesses (76.7).

When PSTs responses to RoC items were investigated, it was seen that, most of the time, they focus on the meaning and significance of new information (90%), they re-evaluate their assumptions when they get confused (81.7%), they think about what they really need to learn before beginning a task (86.7%), they ask themselves questions about how well they are doing while learning something new (78.3%) and they ask themselves if they learned as much as they could have once they finish a task (81.7%).

Based on their mean scores, it can be concluded that PSTs had high levels of knowledge of their learner characteristics, learning strategies and how and when to use them (KoC); and also they had high scores on regulation of cognition component referring to metacognitive activities they use to regulate cognition and control their own learning and thinking. As it can be predicted from their mean scores on the subscales, PSTs were found to be having high levels of metacognitive awareness.

4.1.7. Descriptive Results for Scale of Faith or Worldview Schemas

Examination of the descriptive results for SFWS and its components on a five-point scale revealed that PSTs had the highest score on pluralism subscale (M = 4.43, SD =.59) which assesses participants ideas about showing respect to other beliefs and acknowledging that there is not a single correct belief. When their scores on the literal subscale reversed, their high mean scores (M = 3.56, SD = 1.12) showed that PSTs did not strongly see their beliefs as unchangeable, not interpretable or strict. Their scores on transformation of beliefs subscale (M = 2.39, SD = 1.07) revealed that PSTs' beliefs did not change over time. Their overall faith development score was also found to be high (M = 3.46, SD =.72) indicating that PSTs generally had flexible faiths and respect to other belief systems; however, their religious beliefs do not change.

Concerning literal beliefs, 70.0% of the PSTs did not see their beliefs as distinct and uninterpretable. When transformation of beliefs items was investigated, it was seen that 68.3% of them stated that they did not change their beliefs. Regarding pluralist beliefs, 91.7% of the PSTs thought that everyone's belief and faith is true for them.

Table 4.5. presents a summary of descriptive statistics calculated for all quantitative instruments (STEBI-B, STAS, MAI, and SFWS).

Table 4.5. Descriptive Statistics for Quantitative Instruments

Instrument	Subscales	M	SD
STEBI-B	PSTE	4.04	.39
	STOE	3.58	.47
STAS	-	3.93	.42
MAI	KoC	3.93	.48
	RoC	3.91	.48
SFWS	Literal	3.56	1.12
	Transformation	2.39	1.07
	Pluralism	4.43	.59

4.2. Inferential Statistics

In order to compare PSTs on their different personal characteristics with respect to their NOS understandings, Chi-square Test for Independence and Krukal-Wallis Test were performed.

4.2.1. Chi-square Test for Independence Results for VOSI and VNOS-C

Research Question 3: Is there an association between PSTs' understanding of NOS and NOSI?

In order to perform a Chi-square Test for Independence to investigate research question 1, the general assumptions that apply to all of the non-parametric techniques, random sampling and independence of observations, were assumed to be satisfied. The crosstabulation table (Table 4.6.), which was provided as a part of chi-square analysis, presents the frequencies of PSTs with inadequate, adequate and informed views of NOS and NOSI. The frequencies showed that there might be a possible association between NOS and NOSI views of PSTs; 52 of the participants seemed to have the same understanding level in both of them.

Table 4.6. Views of NOS and Views of NOSI Crosstabulation

		Views of NOSI			
		Inadequate	Adequate	Informed	Total
Views of NOS	Inadequate	20	0	0	20
	Adequate	3	24	0	27
	Informed	0	5	8	13
	Total	23	29	8	60

In order to find out whether there is a statistically significant difference in distribution of frequencies between categories the results of Chi-square Test for Independence was investigated. However, since the distribution of the sample did not meet the assumption of Chi-square analysis such that at least 80 per cent of cells have expected frequencies of 5 or more, Fisher's exact test results were used. The results of Chi-square analysis indicated that the frequency distribution of NOSI understanding of PSTs was not homogenous among PSTs with different levels of NOS understanding; levels of NOS understanding were clustered around some levels of NOSI understandings, X^2 (4, n = 60) = 70.6, p = .000). Cramer's V value was found to be .80 which is accepted as an indication of large effect size for variables with three categories (Pallant, 2007). Therefore, when frequency distribution and chi-square analysis results were evaluated together, it can be concluded that PSTs were tend to have same levels of NOS and NOSI understandings.

4.2.2. Chi-square Test for Independence Results for EWVS and VNOS-C

Research Question 4: Is there an association between PSTs' understanding of NOS and their epistemological world views?

A chi-square test was performed to investigate research question 2. The crosstabulation table (Table 4.7.), which was provided as a part of chi-square analysis, shows the frequencies of PSTs with inadequate, adequate and informed views of NOS and different epistemological world views. The frequencies implied that PSTs with different levels of NOS understanding also had different epistemological world views; they had a homogenous distribution.

Table 4.7. Views of NOS and Epistemological World Views Crosstabulation

		Epistemological World Views				
		Realist	Contextualist	Relativist	Contextualist & Relativist	Total
Views of NOS	Inadequate	4	2	5	9	20
	Adequate	3	5	5	14	27
	Informed	2	1	0	10	13
	Total	9	8	10	33	60

In order to find out whether there is a statistically significant difference in distribution of frequencies between categories the results of Chi-square Test for Independence was investigated. However, since the distribution of the sample did not meet the assumption of Chi-square analysis such that at least 80 per cent of cells have expected frequencies of 5 or more, Fisher's exact test results were used. The results of Chi-square analysis indicated that the frequency distribution of epistemological world views of PSTs was homogenous among PSTs with different levels of NOS understanding; levels of NOS understanding were not clustered around some epistemological world views, X^2 (6, n = 60) = 6.2, p = .411). Therefore, frequency distribution and chi-square analysis results showed that there is no significant association between PSTs' NOS understanding and their epistemological world views.

4.2.3. Kruskal-Wallis Test Results for STEBI-B and VNOS-C

Research Question 5: Do PSTs with different levels of NOS understanding differ in terms of their self-efficacy beliefs regarding science teaching?

In order to perform a Kruskal-Wallis test to investigate research question 3, the general assumptions that apply to all of the non-parametric techniques, random sampling and independence of observations, were assumed to be satisfied. The Kruskal-Wallis test revealed a statistically significant difference in Personal Science Teaching Efficacy (PSTE) scores across three different groups of PSTs with inadequate, adequate and informed views of Nature of Science, X^2(2, n = 60) = 10.72, p = .005. The informed group recorded the highest median score (Md = 4.38) and the inadequate group recorded the lowest median score (Md = 3.88). The median score of adequate group (Md = 3.92) were between two groups. In order to find out which groups scored statistically significant from one another, Mann-Whitney U test were performed as follow-up analyses with a Bonferronni adjusted alpha level of .05/3= .017. Mann Whitney U tests revealed a statistically significant difference in

PSTE scores of informed group (Md = 4.38) and inadequate group (Md = 3.88), U = 261.5, z = -2.91, p = .004. The effect size calculated using the formula r = z / square root of N was found to be .51; large effect size according to Cohen's criteria (1988). The PSTE scores of informed group (Md = 4.38) also differed statistically significant from adequate group (M = 3.92), U = 72.5, z = -2.99, p = .003, r = .47 (medium effect size). Inadequate group and adequate group did not differ from each other significantly, U = 262.5, z = -.16, p = .871. Table 4.8. presents a summary of Mann-Whitney U Test results for PSTE.

Table 4.8. Mann-Whitney U Test Results for PSTE

Groups	N (Total)	Mann-Whitney U	Z	p
Inadequate & Adequate	47	262.5	-.16	.871
Inadequate & Informed	33	261.5	-2.91	.004*
Adequate & Informed	27	72.5,	-2.99	.003*

* The mean difference is significant at the .017 level.

When Science Teaching Outcome Expectancy (STOE) scores of informed, adequate and inadequate groups were compared using a Kruskal-Wallis Test, a statistically significant difference was found between groups, X^2(2, n = 60) = 11.63, p = .003. The informed group recorded the highest median score (Md = 4.10) and the inadequate group recorded the lowest median score (Md = 3.35). The median score of adequate group (Md = 3.70) was between two groups. In order to find out which groups scored statistically significant from one another, Mann-Whitney U test were performed as follow-up analysis with a Bonferronni adjusted alpha level of .05/3=.017. Mann Whitney U tests revealed a statistically significant difference in STOE scores of informed group (Md = 4.10) and inadequate group (Md = 3.35), U = 269.0, z = -2.63, p = .009, r = .48 (medium effect size). The STOE scores of adequate group (Md = 3.70) also differed statistically significant from inadequate group (M = 3.35), U = 134.0, z = -2.94, p = .003, r = .43 (medium effect size). Informed group and adequate group did not differ from each other significantly, U =

127.0, z = -1.41, p = .16. Table 4.9. presents a summary of Mann-Whitney U Test results for STOE.

Table 4.9. Mann-Whitney U Test Results for STOE

Groups	N (Total)	Mann-Whitney U	Z	p
Inadequate & Adequate	47	134.0	-2.94	.003*
Inadequate & Informed	33	269.0	-2.63	.009*
Adequate & Informed	27	127.0	-1.41	.168

* The mean difference is significant at the .017 level.

4.2.4. Kruskal-Wallis Test Results for STAS and VNOS-C

Research Question 6: Do PSTs with different levels of NOS understanding differ in terms of their attitudes towards science teaching?

The Kruskal-Wallis Test showed that there was not a statistically significant difference in STAS scores across three different groups of PSTs with inadequate, adequate and informed views of Nature of Science, X^2(2, n = 60) = 5.28, p =.07. The informed group (Md = 4.18), the adequate group (Md = 3.91) and the inadequate group (Md = 3.82) recorded closer median values to each other.

4.2.5. Kruskal-Wallis Test Results for MAI and VNOS-C

Research Question 7: Do PSTs with different levels of NOS understanding differ in terms of their metacognitive awareness levels?

The Kruskal-Wallis test revealed a statistically significant difference in Knowledge of Cognition (KoC) scores across three different groups of PSTs with inadequate, adequate and informed views of Nature of Science, X^2(2, n = 60) = 14.11, p =.001. The informed group recorded the highest median score (Md = 4.41). The inadequate group and the adequate group recorded equal median scores (Md = 3.76) lower than the informed group. In order to find out which groups scored statistically significant from one another, Mann-Whitney U test were performed as follow-up analyses with a Bonferronni adjusted alpha level of .05/3= .017. Mann Whitney U tests revealed a statistically significant difference in KoC scores of informed group (Md = 4.41) and inadequate group (Md = 3.76), U = 43.5, z = -3.20, p = .001, r = .56 (large effect size). The KoC scores of informed group (Md = 4.41) also differed statistically significant from adequate group (M = 3.76), U = 53.0, z = -3.54, p = .000, r = .56 (large effect size). Inadequate group and adequate group did not differ from each other significantly, U = 266.5, z = -.08, p = .940. Table 4.10. presents a summary of Mann-Whitney U Test results for KoC.

Table 4.10. Mann-Whitney U Test Results for KoC

Groups	N (Total)	Mann-Whitney U	Z	p
Inadequate & Adequate	47	266.5	-.08	.940
Inadequate & Informed	33	43.5	-3.20	.001*
Adequate & Informed	27	53.0	-3.54	.000*

* The mean difference is significant at the .017 level.

When Regulation of Cognition (RoC) scores of informed, adequate and inadequate groups were compared using a Kruskal-Wallis Test, a statistically significant difference was found between groups, X^2(2, n = 60) = 14.01, p =.001. The informed group recorded the highest median score (Md = 4.54) and the adequate group recorded the lowest median score (Md = 3.71). The median score of inadequate group (Md = 3.78) was slightly higher than the adequate group. In order to find out which groups scored statistically significant from one another, Mann-Whitney U test were performed as follow-up analysis with a Bonferronni adjusted alpha level of .05/3=.017. Mann Whitney U tests revealed a statistically significant difference in RoC scores of informed group (Md = 4.54) and inadequate group (Md = 3.78), U = 44.5, z = -3.16, p = .002, r = 0.55 (large effect size). The RoC scores of informed group (Md = 4.54) also differed statistically significant from adequate group (M = 3.71), U = 54.5, z = -3.50, p = .000, r = .55 (large effect size). Inadequate group and adequate group did not differ from each other significantly, U = 242.0, z = -.60, p = .547. Table 4.11. presents a summary of Mann-Whitney U Test results for RoC.

Table 4.11. Mann-Whitney U Test Results for RoC

Groups	N (Total)	Mann-Whitney U	Z	p
Inadequate & Adequate	47	242.0	-.60	.547
Inadequate & Informed	33	44.5	-3.16	.002*
Adequate & Informed	27	54.5	-3.50	.000*

* The mean difference is significant at the .017 level.

4.2.6. Kruskal-Wallis Test Results for SFWS and VNOS-C

Research Question 8: Do PSTs with different levels of NOS understanding differ in terms of their faith/worldview schemas?

The Kruskal-Wallis test showed that there was a statistically significant difference in Faith or Worldview schemas scores across three different groups of PSTs with inadequate, adequate and informed views of Nature of Science, $X^2(2, n = 60) = 7.46$, p = 0.025. The informed group recorded the highest median score (Md = 3.89) and the inadequate group recorded the lowest median score (Md = 3.22). The median score of adequate group (Md = 3.44) was between two groups. In order to find out which groups scored statistically significant from one another, Mann-Whitney U test were performed as follow-up analysis with a Bonferronni adjusted alpha level of .05/3=.017. Mann Whitney U tests revealed a statistically significant difference in faith/worldview scores of informed group (Md = 3.89) and inadequate group (Md = 3.22), U = 60.0, z = -2.59, p = .010, r = .45 (medium effect size). Informed group and adequate group did not differ from each other significantly, U = 94.5, z = -2.34, p = .019. Similarly, adequate group and inadequate group did not differ from each other, U = 258.0, z = -.259, p = .796. Table 4.12. presents a summary of Mann-Whitney U Test results for SFWS.

Table 4.12. Mann-Whitney U Test Results for SFWS

Groups	N (Total)	Mann-Whitney U	Z	p
Inadequate & Adequate	47	258.0	-.259	.796
Inadequate & Informed	33	60.0	-2.59	.010*
Adequate & Informed	27	94.5	-2.34	.019

* The mean difference is significant at the .017 level.

4.3. Summary of the Results

The results of the study revealed that:

- Majority of the participants held adequate and informed views of NOS and NOSI.
- Majority of the participants committed to contextualist and relativist world views together.
- PSTs had high levels of personal science teaching efficacy scores and moderate levels of science teaching outcome expectancies.
- PSTs attitudes towards science teaching was positive.
- PSTs had high levels of metacognitive awareness.
- PSTs generally had flexible faiths.
- There was a significant association between PSTs' understanding of NOS and NOSI.
- There was not any association between PSTs' NOS understanding and their epistemological wold views.
- PSTs with more informed views of NOS had higher self-efficacy beliefs, high levels of metacognitive awareness and more flexible faiths.
- PSTs with different levels of NOS understanding did not differ in terms of their attitudes towards science teaching.

CHAPTER 5

DISCUSSIONS, CONCLUSIONS, IMPLICATONS, RECOMMENDATIONS

In this chapter the major findings of the present study were discussed. Moreover, implications of the study and recommendations for future studies were also addressed.

5.1. Discussions

This section presents a discussion of the results of the present study. The purpose of this study was to investigate the possible associations and relationships between PSTs' NOS understandings and their understanding of NOSI, epistemological world views, self-efficacy beliefs regarding science teaching, attitudes towards science teaching, metacognitive awareness level and faith/worldviews schemas. For this reason, PSTs' understanding of NOS, understanding of NOSI, epistemological world views, self-efficacy beliefs regarding science teaching, attitudes towards science teaching, metacognitive awareness level and faith/worldviews schemas were determined by means of different valid and reliable questionnaires; and, then statistical analyses were conducted to see whether PSTs with different levels of NOS understanding differ in these specific personal characteristics or not.

Descriptive results of the study revealed that most of the participants held adequate and informed understandings of NOS after attending a "Nature of Science and History of Science" course; however, one third of them still had inadequate understandings. Similar results were also found for their NOSI understandings. For other personal characteristics, the results implied that most of the PSTs 1) committed to contextualist and relativist worldviews together, 2) had high personal science teaching efficacy beliefs and moderate levels of science teaching outcome expectancies, 3) had high positive attitudes regarding science teaching, 4) possessed high levels of metacognitive awareness, 5) committed to flexible faith and had respect to other belief systems.

In the following sections, PSTs' understandings of NOS and NOSI, and the possible associations between each of the personal characteristics of PSTs and their NOS understandings were discussed based on the findings of the present study.

5.1.1. PSTs' Understanding of Nature of Science

Research Question 1: What are PSTs' understandings of NOS?

In the present study, sixty PSTs' understandings of seven NOS aspects were determined by means of VNOS-C questionnaire. These aspects were; empirical-basis, subjectivity, tentativeness, theory and law, observation and inference, creativity, and social and cultural embeddedness.

Results of the study revealed that majority of the PSTs held adequate and informed understandings of empirical basis, subjectivity, tentativeness, and creativity aspects of NOS after attending a semester of "Nature of Science and History of Science" course. Although this study did not aimed at investigating the effectiveness of this course and did not followed a pre- post-test design, it can be concluded that students' engagement in NOS-based activities and discussions, and explicitly emphasizing NOS aspects might have helped them develop contemporary views of NOS. As the results of many previous studies also showed that without any efficient NOS instruction, most of the PSTs held inadequate views of these NOS aspects (e.g. Abd-El-Khalick, 2005; Mıhladız, & Doğan, 2012). Therefore, the high percentages of PSTs with adequate and informed views of these NOS aspects might be attributed to the positive influence of the course. Previous research showed that after receiving an explicit-reflective instruction of NOS, PSTs were able to improve their views of various NOS aspects (e.g. Akerson, Morrison, & McDuffe, 2006; Bell, Matkins, & Gansneder, 2011).

On the other hand, most of the PSTs had trouble with theory and law, observation and inference, and social and cultural embeddedness aspects of NOS; majority of them held inadequate understanding of these aspects. Their views were superficial and they were generally not able to define them clearly and explain the relationship between them. Similarly, even though most of them realized that society might have an effect on science, they could not clarify how and why this effect occurs. This finding is also consistent with previous research (e.g. McDonald, 2010; Mıhladız, & Doğan, 2012). Jones (2010) suggested that students' misconceptions related to scientific theories and laws might arise from misuse of the term hypothesis; they generally see a hierarchical relationship between hypotheses, theories and laws, and for this reason, they think that theories are the prior step of laws, not well supported and need to be completed to become a law. In a similar way, their lack of knowledge about observations, inferences and their importance during the development of scientific knowledge might be attributed to their tendency to ignore the importance of inferences; they do not realize that an observation need to be interpreted, they think that scientific knowledge is discovered through direct observations (Abd-El-Khalick, & Akerson, 2004). Moreover, PSTs generally think that science is isolated from the society and the only connection between science and society is related to funding research (Abd-El-Khalick, 2005). In general, PSTs misunderstandings were similar to the ones previously reported in the literature. There might be different reasons behind them; however, all of them need to be eliminated in order to raise teachers with contemporary views of NOS. If we cannot help them develop more informed views of NOS, we cannot expect them to facilitate their future students' learning of contemporary views of NOS.

In summary, most of the PSTs held adequate and informed understandings of NOS when their views of specific aspects were investigated together and their overall NOS understanding were determined. However, there were some aspects they did not generally understand and some PSTs holding inadequate views of many of the NOS aspects; that might be related to other characteristics (Akerson, & Donnely, 2008).

5.1.2. PSTs' Understanding of Nature of Scientific Inquiry

Research Question 2: What are PSTs' understandings of NOSI?

In the present study, sixty PSTs' understandings of seven NOSI aspects were determined by means of VOSI questionnaire. These aspects were; guide of questions, justification, multiple methods, multiple purposes, data and evidence, scientific models and community of practice.

Similar to their NOS understanding results, majority of PSTs held adequate and informed understandings of the target NOSI aspects. This could be explained by the close relationship between NOS and NOSI aspects; they are all interrelated. Although during the NOS course there were not any explicit emphasis on the NOSI aspects, they would have been mentioned when the related NOS aspect was discussed. For example, with empirical-basis aspect of NOS, PSTs could have realize the importance of questions, data and evidence; or with social and cultural embeddedness aspect of NOS, PSTs could have understand the community of practice aspect of NOSI. Similarly, when subjectivity aspect of NOS was discussed, the myth of a single scientific method would have been discussed. However, the frequencies of inadequate views of the target NOSI aspects were higher than the inadequate views of the NOS aspects. That might be because NOS aspects were clearly addressed during the course whereas NOSI aspects did not. About 38% of the participants held inadequate views of NOSI and much should be done to improve PSTs' views of NOSI.

In particular, most of the PSTs had inadequate views of scientific models and guide of questions aspects of NOSI. Most of the PSTs just stated the name of a popular scientific model, such as DNA model or atom model. In a previous study, Schwartz (2007) also reported that most of the PSTs only focus on the explanatory qualities of scientific models, ignoring their importance during the further studies. This might be because PSTs generally think of models as simpler, illustrative versions of theoretical information; they do not value them as much as the explanations behind them. In a similar way, PSTs do not realize the importance of questions; they generally think a hypothesis is the beginning statement of a scientific research (Schwartz, Lederman, & Lederman, 2008). These misconceptions should also be eliminated because they might block their understanding of NOS. It is reasonable to assume that a person who did not value scientific models or questions might also not value theories, observations, interpretations and creativity.

In conclusion, it can be thought that the explicit-reflective instruction of NOS aspects not only helped them develop their NOS views but also their NOSI views. Previous research also showed that explicit-reflective instruction is effective in facilitating learners' understanding of NOSI (Gess-Newsome, 2002; Lederman et al., 2003). However, since NOSI was not mentioned explicitly, their NOSI views were not as informed as their NOS views; the focus was on NOS throughout the course.

5.1.3. Nature of Science and Nature of Scientific Inquiry

Research Question 3: Is there an association between PSTs' understanding of NOS and NOSI?

In order to investigate whether there was a possible association between NOS and NOSI views of the participants, a Chi-square Test for Independence was conducted and it was seen that 86.7% of the participants had the same level of understanding of NOS and NOSI. That is when a participant had an adequate understanding of NOS, s/he tends to have an adequate understanding of NOSI, too. It was also found that none of the participants held a more developed view of NOSI than NOS; there were not any PSTs who held an inadequate/adequate view of NOS but an adequate/informed view of NOSI; but vice versa was true.

In general, learners' understanding of scientific inquiry has been included in understanding of NOS; however, NOS aspects are concerned with the product of inquiry whereas NOSI aspects are concerned with the processes of the inquiry (Schwartz, Lederman, & Lederman, 2008). Therefore, understanding of NOS and NOSI might have been related to each other in such a way that if you do not know the process you do not understand the product (or vice versa). Understanding the nature of scientific inquiry, the processes of generating scientific knowledge, might help learners more easily comprehend the characteristics of scientific knowledge. Similarly, understanding of NOS might also develop their understanding of NOSI. There might not be a direct relationship as one improves the other, but they can both facilitate understanding of the other. Moreover, researchers emphasized that doing scientific inquiry and understanding its nature is an important step for being able to understand the nature of science, and designed projects, programs, authentic experiences and so on to develop learners' NOS views (Bell, Blair, Crawford, & Lederman, 2003).

The results of this study also supported that PSTs with inadequate views of NOSI, generally held inadequate views of NOS also; only three of them had adequate views. Similarly, most of the PSTs holding adequate views of NOSI held adequate views of NOS; only five of them had informed views. Finally, all of the PSTs with informed views of NOSI also had informed views of NOS. Therefore, it can be concluded that as engagement in scientific inquiry and understanding of NOS are related, understanding of NOSI and NOS might also be related to each other; if learners are provided a clear and explicit instruction of NOSI instead of just doing inquiry, they might learn NOS better. As Rowe (1978) stated "John Dewey never said that we learn by doing. He said that we learn by doing and by thinking about what we’re doing" (p. 216).

In addition, it could not be determined whether understanding of NOSI helps learners to develop more informed views of NOS or it is the other way; however, the results indicated that there is a possible association between them. Therefore, an explicit instruction of both NOS and NOSI might be an effective way to facilitate learners' understanding of science, its characteristics, processes and products.

5.1.4. Nature of Science and Epistemological World Views

Research Question 4: Is there an association between PSTs' understanding of NOS and their epistemological world views?

In order to investigate whether there was a possible association between PSTs understanding of NOS and their epistemological world views, a Chi-Square Test for Independence was conducted and it was seen that the distribution of epistemological world views of PSTs was homogenous among PSTs with different levels of NOS understanding; levels of NOS understanding were not clustered around some epistemological world views. The PSTs had a homogenous distribution among both of the variables.

First of all, it was seen that most of the PSTs committed to contextualist and relativist world views together. Similar results were found before (Schraw, & Olafson, 2002; Olafson, & Schraw, 2006) and it was concluded that PSTs tended to have a blended epistemological world view. That means they both agreed with the statements "Students are expected to construct their own understanding; however, all understandings are not equally valid, some conclusions are better than others. Moreover, teacher can teach some skills to the students but they also need to learn some of them on their own." (contextualist) and "Students need to know there are different ways to understand scientific information. Scientific knowledge is tentative; therefore, students should question and evaluate the scientific information. Teachers should not influence their students' knowledge; they should create an environment where students think independently" (relativist). Based on the previous research, Olafson and Schraw (2006) asserted that PSTs do not blend different world views consciously; they naively select different world views because they do not examine their beliefs carefully to commit to a consistent world view. In the present study, it was not specifically investigated whether PSTs did a conscious or naïve selection; however, the results showed that even the PSTs with inadequate views of NOS and scientific knowledge had a blended world view. Since it would be hard for a person who do not know about science and scientific knowledge enough to carefully assess two different world views and consciously select a blended view; it can be concluded that a blended world view is generally a result of naivety.

Moreover, other researchers argued that a realist world view is associated with less sophisticated beliefs about knowledge whereas contextualist and relativist world views are associated with more sophisticated beliefs (Schommer-Aikins, 2002; Olafson, & Schraw, 2006). Similarly, Tsai (2002) found that PSTs' beliefs about teaching and learning science, and nature of science were highly related to one another. However, Yılmaz-Tüzün and Topçu (2008) found that even though PSTs had less sophisticated epistemological beliefs, thinking that science can be best thought when students think of science as unchangeable and memorize scientific information, they committed to relativist world view emphasizing the effectiveness of student-centered teaching methods. Therefore, it can be concluded that although relativist and contextualist world views are considered to be associated with more sophisticated beliefs, PSTs do not necessarily commit to them as a result of a serious sophisticated thinking process. In a similar way, in the present study, a relationship was not found between PSTs' epistemological world views and their understanding of NOS. This might be because of the science teacher education program and the science and technology curriculum in Turkey strongly emphasize a "constructivist" approach, which is closer to relativist and contextualist world views. Therefore, PSTs might have thought that they should select one of these world views or both of them because they are better for science teachers. That is although they do not possess an adequate or informed understanding of NOS, they know contextualist and relativist world views are more accepted to be effective in science education.

In conclusion, even though an association between NOS understanding and epistemological worldviews was not found, it was found that most of the PSTs committed to relativist and contextualist worldviews which were considered as indicators of more sophisticated beliefs of science teaching. However, since PSTs with inadequate views of NOS also selected these worldviews, this commitment might not be as sophisticated as it was thought. With a qualitative study, investigating PSTs epistemological worldviews, a more detailed and solid conclusion could be drawn.

5.1.5. Nature of Science and Science Teaching Self-Efficacy

Research Question 5: Do PSTs with different levels of NOS understanding differ in terms of their self-efficacy beliefs regarding science teaching?

The findings of this study revealed that PSTs with inadequate, adequate and informed understandings of NOS differed in PSTE (personal science teaching efficacy) and STOE (science teaching outcome expectancy) scores significantly. Regarding PSTE scores, informed group differed from inadequate and adequate group significantly, whereas adequate and inadequate group did not differ from each other. When STOE scores were investigated, it was seen that informed and adequate groups differed from inadequate group significantly; however, did not differ from each other.

Personal science teaching efficacy, one's beliefs about their abilities in teaching science, found to be directly related to science content knowledge in a previous study by Bleicher and Lindgren (2005). Tekkaya, Çakıroğlu, and Özkan (2004) also found that PSTs' PSTE scores were related to their science content knowledge. That is PSTs with a higher science content knowledge tended to have higher personal science teaching efficacy beliefs. Similarly, in the present study it was found that there is a relationship between science teaching self-efficacy and understanding of NOS; PSTs with informed views of NOS had higher personal science teaching self-efficacy beliefs than PSTs with adequate and inadequate views. However, it could not be determined whether science teaching self-efficacy has an effect on NOS understanding or vice versa. In a previous study, Hanson (2006) found that science teaching self-efficacy does not influence development of NOS understanding but a better understanding of NOS results in higher self-efficacy beliefs. The present study also provided evidence that there might be a relationship between these two variables; however, in order to better understand this relationship and which variable affects the other, further research should be conducted. Moreover, a significant difference could not been found between adequate group and inadequate group; this seems contradicting with the idea of NOS views and self-efficacy beliefs are related to each other. Although the difference was not significant, adequate group had higher scores than the inadequate group. That is PSTs who had more informed views of NOS had more confidence in teaching science and think that they would be efficient as a science teacher. Therefore, the possibility of a relationship still exists, but further research is required to draw a more well-grounded conclusion.

In a similar way, science teaching outcome expectancy, one's beliefs about their effectiveness on students' achievement, found to be directly related to their NOS understanding. That is PSTs with more informed views of NOS had higher science teaching outcome expectancies. In the previous studies, Tekkaya, Çakıroğlu and Özkan (2004) and Bleicher and Lindgren (2005) did not find any relationship between science teaching outcome expectancy and science content knowledge.

Similarly, Hanson (2006) suggested that NOS understanding and science teaching outcome expectancy were not related to each other. However, the findings of the present study suggested that there is a relationship between PSTs' NOS understanding and their science teaching outcome expectancies. That is PSTs who had more informed views of NOS think they will be effective on students' achievement in science. Therfore, the relationship between science teaching outcome expectancies and NOS understanding is inconclusive. With further research, more detailed information about this relationship can be obtained. Although the difference between adequate and informed group was not significant, when median scores of the two groups were investigated, informed group had obviously higher scores than the adequate group. The difference between these two groups was even larger than the difference between inadequate and adequate groups. Non-significance of this difference might be attributed to the sample size of these two groups.

High self-efficacy beliefs are considered o be important and positive in science education because previously it was found that the level of efficacy also related to the amount of effort a teacher spent in teaching, the level of professional commitment, teachers' willingness to help students who have difficulties in learning the content, students' achievement, students' attitudes towards school and content, and teachers' attitudes towards teaching science (Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998). The results of the present study revealed that PSTs generally had high personal science teaching efficacy beliefs and positive outcome expectancies, and these efficacy beliefs seem to be related to their understanding of NOS. Regarding the previous literature suggesting that there is a relationship between science content knowledge and efficacy beliefs, this result is not surprising; NOS also can be considered as a science topic. Accordingly, it can be inferred that higher self-efficacy beliefs are associated with more informed views of NOS, and these result in positive classroom behaviors of teachers. Whether NOS understanding facilitates self-efficacy or vice versa, increasing both of these variables in PSTs had positive outcomes in science teaching, therefore, much should be done to enhance improve both of them.

In conclusion, there is a possible relationship between PSTs' understanding of NOS and their science teaching self-efficacy beliefs; however, in order to understand the direction of this relationship and determine which variable affect the other, future research is needed. With a more detailed investigation, it might be possible to find out whether self-efficacy influences NOS understanding or vice versa. It is also possible that both of these variables influence each other.

5.1.6. Nature of Science and Attitudes towards Science Teaching

Research Question 6: Do PSTs with different levels of NOS understanding differ in terms of their attitudes towards science teaching?

In order to investigate research question 6, a Kruskal-Wallis Test was performed and it was found that PSTs with different levels of NOS understanding did not differ in terms of their attitudes towards science teaching. All of the groups (inadequate, adequate and informed) recorded high science teaching attitude scores.

Although a significant relationship was not found between NOS understanding and attitudes towards science teaching; the results of the present study revealed that participants generally held positive attitudes towards teaching science. Since attitudes are important in shaping behavior (Tippins, & Koballa, 1991) and have an influence on classroom practice (Brand, & Wilkins, 2007), PSTs' positive attitudes regarding science teaching are promising and pleasing for their future classroom practices.

In the present study, all of the PSTs regardless of their level of NOS understanding were found to have high positive attitudes towards science teaching. Similar results were found in the previous studies investigating the relationship between attitudes towards science teaching and NOS understanding. For example, Harty, Samuel and Andersen (1991) also found NOS understanding is related to neither attitudes towards science nor attitudes towards science teaching. On the other hand, Tsai (2002) claimed that teachers' beliefs about teaching and learning are related to their beliefs about science. Muğaloğlu and Bayram (2010) also suggested that an increase in learners' positive attitudes towards science teaching was likely to improve their NOS views. Therefore, since there are still limited studies about the relationship between attitudes towards science teaching and their NOS understanding, it is hard to draw a conclusion. Future research is needed to be able to explain the possible relationship between NOS understanding and attitudes towards science teaching.

5.1.7. Nature of Science and Metacognitive Awareness

Research Question 7: Do PSTs with different levels of NOS understanding differ in terms of their metacognitive awareness levels?

The results of the present study revealed that regarding Knowledge of Cognition (KoC) and Regulation of Cognition (RoC) components of metacognitive awareness, PSTs with informed views of NOS had significantly higher scores than PSTs with adequate and inadequate views. That is a relationship between metacognitive awareness level and NOS understanding was found. Although the inadequate and adequate groups did not differ from each other, the significant difference with large effect size between informed group and these two groups still indicate a possible relationship between metacognitive awareness and NOS understanding.

Previous studies also supported the relationship between metacognition and NOS understanding. For example, Abd-El-Khalick and Akerson (2009) investigated the influence of metacognitive strategies training on PSTs' understanding of NOS and found that PSTs who received the training achieved significantly higher gains in their

NOS understandings. They concluded that more informed views of NOS are related to higher levels of metacognitive awareness. Peters and Kitsansas (2010) also found similar results. Moreover, in the literature, it was previously shown that the effect of metacognitive strategies are not content-specific, it has been found to be effective in learning in various content areas (Abd-El-Khalick, & Akerson, 2009). In addition, Thomas (2012) asserted that metacognition is a key to develop scientific literacy, understand nature of scientific inquiry, nature of science and science concepts. The results of the present study also supported the previous literature suggesting that metacognition helps learners monitor, plan and sequence their learning and thinking processes in a way that enhances their performance (Schraw, & Dennison, 1994; Sungur, & Senler, 2009). It was seen that PSTs with informed views of NOS had much more higher metacognitive awareness levels than PSTs with adequate and inadequate views.

Based on the findings of the previous studies and findings of the present study, it can be inferred that higher levels of metacognitive awareness might have helped PSTs developed more informed views of NOS. Metacognitive abilities help individuals use strategies to facilitate their learning, understand their strengths and weaknesses, motivate themselves and evaluate themselves; and by this way facilitate their learning. For this reason, gaining PSTs these abilities help them improve their learning of NOS as well as other science subjects.

In conclusion, it was found that higher levels of metacognitive awareness are associated with higher levels of NOS understanding. With more detailed future research, more evidence could be obtained that supports the integration of metacognition in science education.

5.1.8. Nature of Science and Faith/Worldviews

Research Question 8: Do PSTs with different levels of NOS understanding differ in terms of their faith/worldview schemas?

The findings of this study revealed that PSTs with different levels of NOS understanding had different faith/worldviews schemas. A significant difference between informed group and inadequate group was found; however, adequate group did not differ from any of these two groups. Nevertheless it was seen that PSTs scores on faith/worldview schemas scale got higher as their level of NOS understanding increased. That means as PSTs' with higher levels of NOS understanding tended to have more flexible faith/worldviews.

In the previous studies, it was consistently found that when learners' religious beliefs contradict with scientific knowledge, they tend to choose religion over science and they resist to learn that scientific information. For example, Roth and Alexander (1997) found that students' strong religious beliefs prevent them gain an informed understanding of NOS. Similar results were found in the studies of Haidar (1999), Abd-El-Khalick and Akerson (2004), Muğaloğlu and Bayram (2010). Consistent with the previous studies, in the present study it was also found that as PSTs worldviews get more flexible, not seeing their religious beliefs completely dogmatic and realizing that other belief systems might be true for other people, their views of NOS tend to be more informed. When they show strong commitment to their own worldviews, they ignore the possibility of any other belief to be true. Similarly, when they think science as contradictory to their beliefs, they also tend to ignore it, too. However, this does not mean learners need to choose either science or their religious beliefs. Abd-El-Khalick and Akerson (2004) reported that when PSTs were able to differentiate scientific way and religious way of knowing, they could develop informed views of NOS even though they held strong religious beliefs. The important thing is to help learners realize the distinction between religion and science, and do not see them in opposition to each other.

As PSTs' low scores on transformation of beliefs subscale in the present study indicated, a person's religious beliefs are generally stable and resist to change. They are dogmatic and not open to interpretation. Therefore, when scientific knowledge contradicts with these strict beliefs, PSTs' generally reject scientific ideas. As their beliefs get flexible, they become more open to accept new ideas and other beliefs, their understanding of NOS also develops. For this reason, in science education NOS should be presented in such a way that learners should not feel threatened in terms of their religious beliefs.

5.2. Conclusions

In the present study, many interesting relationships were found between PSTs' understanding of NOS and their other personal characteristics. First of all, the findings revealed that PSTs understanding of NOS and NOSI are highly related; therefore, since both concepts have crucial importance in development of scientific literacy, this finding might be useful while making instructional decisions in science education. Similarly, self-efficacy beliefs regarding science teaching, metacognitive awareness levels and faith/worldviews of the PSTs were found to be significantly related to understanding of NOS. The results of the similar previous studies also supported these results. Thus, it can be concluded that even though the effectiveness of an instructional technique is proven before, there might be other factors interfering with the learning processes of NOS. There have been many studies aimed to improve learners' understanding of NOS by using various different techniques (e.g. Abd-El-Khalick, & Akerson, 2004; Bell, Blair, Crawford, & Lederman, 2003; Khishfe, & Lederman, 2006; Morrison, Raab, & Ingram, 2009; Solomon, Duveen, Scot, & McCarthy, 1992; Yacoubian, & BouJaoude, 2010); however, all of these studies focused on the intervention ignoring other variables that might have an influence on the effectiveness of the instructional technique. This might also be one of the reasons behind the different results of the studies that followed similar studies with similar participants. For this reason, it is important to identify these variables before making an instructional decision.

On the other hand, there were not any significant associations between PSTs' epistemological world views, attitudes towards science teaching and understanding of NOS. However, some of the previous studies suggested that there might be a possible relationship between these variables. Since there are still limited studies investigating the relationships between personal characteristics and NOS understanding, it is hard to drive a well-grounded conclusion.

5.3. Implications and Recommendations for Further Studies

In this study, the possible relationships between PSTs' understanding of NOS and their understanding of NOSI, epistemological world views, self-efficacy beliefs regarding science teaching, attitudes towards science teaching, metacognitive awareness levels and faith/worldview schemas were investigated. Since understanding of NOS has been considered as a crucial component of scientific literacy, the main goal of science education (NSTA, 1971; MoNE, 2004), gaining PSTs informed views of NOS and preparing them for their future science classes has been an important focus of studies in science education.

Although the previous studies have consistently showed that majority of the PSTs held inadequate views of NOS (Lederman, 2007), in the present study, it was found that majority of the PSTs held adequate and informed views of NOS. This result might be attributed to the effectiveness of NOS instruction they received during a semester; as the previous studies consistently showed an explicit-reflective approach of teaching NOS is successful in gaining PSTs a meaningful understanding of NOS. However, there were still some PSTs with inadequate views of NOS and its aspects;

therefore, much should be done to enhance its effectiveness. Therefore, this finding might be useful for science teachers, science teacher educators, and policy makers while planning NOS instruction. Similarly, most of the participants held adequate and informed views of NOSI, even though they did not receive an explicit NOSI instruction. The interrelated aspects of NOS and NOSI might have facilitated understanding of each other. This finding might also imply that a well-programmed instruction of NOS might provide a better understanding of both of the concepts as well as their understanding of science in general. The results of the study conducted by Schwartz (2007) also suggested that explicit-reflective NOS instruction is effective in developing learners' views of NOS and NOSI. However, more future research need to be conducted in order to describe the most effective ways of improving learners' views of NOS and NOSI. With the help of future experimental studies investigating and comparing the effectiveness of different techniques, a more solid conclusion might be drawn about how to improve learners' understandings of NOS and NOSI.

Another interesting finding of this study was the associations between NOS understanding and other personal characteristics. The factors affecting learners' understanding of NOS and the relationships between personal characteristics and NOS have become rising research topics in recent years in science education. Similar to the present study, most of the studies revealed many interesting associations between different characteristics of learners and their NOS views. For example, the present study revealed that understanding of NOSI, self-efficacy beliefs regarding science teaching, metacognitive awareness, and faith/worldview of the PSTs might have a relationship with their NOS understandings. Based on the findings it was concluded that PSTs with more informed views of NOSI, higher self-efficacy beliefs regarding science teaching, higher levels of metacognitive awareness and more flexible faith/worldviews tend to have more informed views of NOS. On the other hand, their attitudes towards science teaching and epistemological world views were not found to be related to their NOS understanding. These findings might be useful while planning an effective NOS instruction and trying to improve PSTs understanding of NOS. For example, PSTs' science teaching self-efficacy beliefs and metacognitive awareness levels could be tried to improve in order to enhance understanding of NOS. Moreover, NOS could be presented in such a way that PSTs do not feel threatened in terms of their religious beliefs. In conclusion, the results implied that even though the instructional strategies were developed perfectly, there might be some other factors interfering with the learning process. However, since the number of the studies regarding this issue is still limited, an extensive amount of future research is needed.

For future studies, an experimental study with pre-test post-test control group design which do not only investigate the effectiveness of the NOS instruction, but also takes into consideration the personal characteristics might be conducted. By this way, the relationships between personal characteristics and NOS understandings and directions of these relationships might be determined. For example, if all of the other variables and NOS understandings were measured before and after a NOS intervention, it could be determined whether a specific variable influences NOS understanding or vice versa.

In addition, there are various other characteristics that might interfere with the learning processes such as concerns, motivation, academic background, learning styles, science content knowledge, prior NOS conceptions and so on. The relationship of these different characteristics with NOS understanding could also be investigated. Moreover, while investigating these relationships different techniques could be used. For example, Muğaloğlu and Bayram (2010) proposed a viable structural model to understand the relationships between NOS understanding and factors that might affect it. Future studies regarding how to control, overcome or benefit from these relationships while trying to improve learners’ NOS views are also needed. It would also reveal interesting results if these other characteristics are specified to NOS in such a way that efficacy beliefs regarding NOS teaching, attitudes towards learning and teaching NOS, motivation and concerns for teaching and learning NOS, metacognition for NOS and so on.

Besides, with quantitative studies the sample size could be increased in order to improve generalizability of the results. Qualitative studies are also needed to be able to explain these relationships in detail. With qualitative data, not restricted to questionnaires but also extended to observations, interviews, reflective papers, artifacts and so on, much more information could be gathered not only about the relationships but also the reasons behind them.

Lastly, the relationships between personal characteristics of PSTs and their classroom practices might be investigated. By this way, the effect of these characteristics on their future classroom NOS practices could be determined. Moreover, this might also be helpful to identify and eliminate negative factors affecting the quality of NOS instruction.

In conclusion, the findings of the present study provide a ground work for future studies by describing many interesting relationships between personal characteristics and NOS understanding. These relationships might be useful for science teachers, science teacher educators and policy makers while planning NOS instruction; PSTs personal characteristics might be taken into account while organizing the objectives and content of the science teacher education programs. With the help of the present study, previous studies and future studies, better ways to enhance learners' understanding of NOS might be found. It is important to identify all of the variables that might affect a process before trying to perfectly complete the process. By this way, we can find ways of controlling them or turning them to good accounts.

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APPENDICES

APPENDIX A

KİŞİSEL BİLGİLER FORMU

1. Cinsiyetiniz: ☐ Kadın ☐ Erkek
2. Doğum tarihiniz: _______________
3. Genel Not Ortalamanız:_________________
4. Mezun olduğunuz lise türü:
   ☐ Anadolu Lisesi ☐ Öğretmen Lisesi ☐ Düz Lise ☐ Diğer:______________

5. Annenizin eğitim düzeyi:
   ☐Hiç okula gitmemiş ☐ İlkokul ☐ Ortaokul ☐ Lise ☐ Üniversite ☐ Lisansüstü

6. Babanızın eğitim düzeyi:
   ☐Hiç okula gitmemiş ☐ İlkokul ☐ Ortaokul ☐ Lise ☐ Üniversite ☐ Lisansüstü

7. Bu dönem almış olduğunuz dersler de dahil olmak üzere fen alanıyla ilgili aşağıdaki derslerden hangilerini aldınız?
   ☐ Genel Fizik I ☐ Genel Fizik II ☐ Genel Fizik III
   ☐ Modern Fiziğe Giriş ☐ Genel Kimya I ☐ Genel Kimya II
   ☐ Genel Kimya III ☐ Genel Kimya IV ☐ Genel Biyoloji I
   ☐ Genel Biyoloji II ☐ İnsan Anatomisi ve Fiz. ☐ Fizikte Özel K.
   ☐ Kimyada Özel Konular ☐ Gen. ve Biyoteknoloji ☐Evrim
   ☐ Biyolojide Özel Konular ☐ Astronomi

8. Bu dönem almış olduğunuz dersler de dahil olmak üzere eğitim alanıyla ilgili aşağıdaki derslerden hangilerini aldınız?

☐ Eğitim Bilimine Giriş ☐ Eğitim Psikolojisi ☐ Öğrt. ilke ve Yönt.
☐ Fen - Tek. Prog. ve Plan. ☐ Özel Öğrt. Yönt. I ☐ Özel Öğrt. Yönt. II
☐ Okul Deneyimi ☐ Öğretmenlik Uyg. ☐ Rehberlik
☐ Sınıf Yönetimi ☐ Öğrt. Tekn. ve Mat. Tas.
☐ Türk Eğt. Sist. ve Okul Yön.

9. Daha önce hiç öğretmenlik tecrübeniz oldu mu? ☐ Evet ☐ Hayır

Cevabınız **EVET** ise**,** lütfen kısaca
bahsediniz.____
____

10. Daha önce hiç bilimin doğasıyla ilgili başka bir ders aldınız mı? Ya da aldığınız başka bir dersin içerisinde bilimin doğasına yer verildi mi? Bilimin doğasıyla ilgili başka herhangi bir etkinliğe katıldınız mı (seminer, sunum vs.)?

☐ Evet ☐ Hayır

Cevabınız **EVET** ise**,** lütfen kısaca
bahsediniz**.**____
____

11. Bilimin doğasıyla ilgili ne kadar bilgili olduğunuzu düşünüyorsunuz?

☐ Hiç ☐ Çok az ☐ Yeterli derecede ☐Çok iyi

12. Gelecekte öğrencilerinize bilimin doğasını öğretirken ne kadar başarılı olacağınızı düşünüyorsunuz?

☐ Hiç ☐ Çok az ☐ Yeterli derecede ☐Çok iyi

APPENDIX B

BİLİMİN DOĞASI HAKKINDA GÖRÜŞLER ANKETİ (VNOS-C)

1. Sizce bilim nedir? Bilimi (ya da fizik, kimya, biyoloji gibi bilimsel alanları) din ve felsefe gibi disiplinlerden ayıran nedir? Açıklayınız.

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2. Deney sizce nedir?

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3. Bilimsel bir bilginin gelişmesi için deney gerekli midir? ☐ Evet ☐ Hayır

?? Eğer cevabınız **EVET** ise neden böyle düşündüğünüzü açıklayınız.

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?? Eğer cevabınız **HAYIR** ise neden böyle düşündüğünüzü açıklayınız.

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4. Bilim insanları bilimsel bir teoriyi geliştirdikten sonra (Ör: Atom teorisi, evrim teorisi) bu teori zamanla değişir mi? ☐ Evet ☐ Hayır

?? Eğer cevabınız **HAYIR** ise (bilimsel teorilerin değişmeyeceğine inanıyorsanız) nedenini örneklerle açıklayınız.

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?? Eğer cevabınız **EVET** ise (bilimsel teorilerin değişeceğine inanıyorsanız);

(a) Teoriler niçin değişir, açıklayınız

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(b) Sizce neden bu durumda bilimsel teorileri öğreniyoruz. Görüşlerinizi örneklerle açıklayınız.

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5. Bilimsel teori ile bilimsel kanun arasında bir fark var mıdır? Cevabınızı bir örnekle açıklayınız.

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6. Fen kitaplarında sık sık atom; merkezinde bir çekirdek, çekirdeğin etrafında dönen; proton (pozitif yüklü partiküller) ve nötronlar (nötr partiküller) ile elektronlardan (negatif yüklü partiküller) oluşur. Bilim insanları atomun bu yapısı hakkında ne kadar emindirler. Bilim insanlarının atomun neye benzediğine karar vermek için ne tür kanıtlar kullandıklarını düşünüyorsunuz?
   ....
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   ....
7. Fen kitaplarında sık sık; ortak bir atadan gelen, birbirleriyle benzer özellikler gösteren ve çiftleştiklerinde verimli fertler meydana getirebilen canlıların oluşturduğu gruba "tür" denildiğini yazar. Bilim insanları bir türün özellikleri hakkında ne kadar emin olabilirler? Bilim insanları bir türü tanımlamak için ne tür kanıtlar kullanırlar?
   ....
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   ....
8. Dinozorların 65 milyon yıl önce yok olduklarına inanılır. Bilim insanları tarafından dinozorların yok oluşunu açıklayan hipotezlerden iki tanesi büyük destek bulur. Birincisi; bir grup bilim insanı 65 milyon yıl önce büyük bir meteorun dünyaya çarptığını ve bir seri yok olma olaylarına sebep olduğunu öne sürer. İkince hipotez; diğer bir grup bilim insanı büyük ve şiddetli bir volkanik patlamanın bu yok oluşa neden olduğunu öne sürer. Her iki grup bilim insanı da aynı bilgilere ulaşıp kullanmalarına rağmen bu farklı sonuçlara nasıl ulaşırlar?
   ....
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   ....

9. Bazı iddialara göre bilim toplumsal ve kültürel değerlerden etkilenir. Yani bilim, uygulandığı kültürün; toplumsal ve politik değerleri, filozofik varsayımları ve entelektüel normları yansıtır. Diğer iddialar bilimin evrensel olduğudur. Yani, bilim ulusal ve kültürel sınırları aşar, uygulandığı yerdeki toplumsal ve politik değerler, filozofik varsayımlar ve entelektüel normlardan etkilenmez.

?? Eğer bilimin sosyal ve kültürel değerleri yansıttığını düşünüyorsanız, örnek vererek açıklayınız.

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?? Eğer bilimin evrensel olduğunu düşünüyorsanız örnek vererek açıklayınız.

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10. Bilim insanları sorularına yaptıkları deneyler ve araştırmalar yardımıyla cevap bulmaya çalışırlar. Sizce bilim insanları bunu yaparken hayal güçlerini ve yaratıcılıklarını kullanırlar mı? ☐ Evet ☐ Hayır

?? Eğer cevabınız **EVET** ise sizce bilim insanları hayal gücü ve yaratıcılıklarını araştırmalarının; planlama, deney yapma, gözlem yapma, verileri analiz etme, sonuçları açıklama ve yorumlama gibi aşamaların hangisinde kullanırlar? Lütfen bilim insanlarının niçin hayal gücü ve yaratıcılığı kullandığını örneklerle açıklayınız.

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?? Eğer cevabınız **HAYIR** ise neden böyle düşündüğünüzü uygun örneklerle açıklayınız.

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APPENDIX C

BİLİMSEL SORGULAMA HAKKINDA GÖRÜŞLER ANKETİ (VOSI)

1. Bilimsel yöntem genellikle hipotez kurma, değişkenleri belirleme (bağımlı/bağımsız), deney tasarlama, veri toplama ve verileri sunma basamaklarının izlenmesi olarak tanımlanır. Sizce bilimin doğru ilerleyebilmesi için, bilim insanları bu bilimsel yöntemi izlemeliler midir? ☐ Evet ☐ Hayır

   ?? Eğer cevabınız **EVET** ise (tüm bilimsel araştırmalarda standart basamaklar/yöntemler izlenmelidir düşüncesindeyseniz), neden bilim insanlarının bu yöntemi kullanması gerektiğini açıklayınız.

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   ?? Eğer cevabınız **HAYIR** ise (birden fazla, farklı bilimsel yöntemler olduğu düşüncesindeyseniz), bu araştırmalarda yöntemlerinin nasıl farklı olabildiğini ve buna rağmen nasıl bilimsel olarak kabul edilebildiklerini açıklayınız.

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2. Modeller bilimde sıklıkla kullanılırlar. Size göre bilimsel model nedir? Açıklayınız ve bir örnek veriniz.

   Bilimsel Model...

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   Bilimsel modele bir örnek veriniz: ....

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3. Bilim insanları pek çok araştırma yaparlar ve daha sonra bulgularını diğer insanlarla paylaşırlar. Çalışmalarını bilimsel dergilerde yayınlarlar. Toplantılarda ve hatta televizyonda çalışmaları hakkında konuşurlar. Sizce bilim insanları araştırma sonuçlarının açıklanmaya ve diğer insanlarla paylaşılmaya hazır olduğuna nasıl karar verirler? Diğer insanları bulgularının geçerli (inanılabilir) olduğuna ikna edebilmek için ne tür bir bilgiye ihtiyaç duyarlar?

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4. Bilim insanları (biyologlar, kimyagerler, fizikçiler, yer bilimciler vb.) dünyamız hakkında bilgi sahibi olmak için ne gibi çalışmalar yaparlar? Bilim insanlarının bu çalışmaları nasıl yaptıklarını açıklayınız.

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5. Bilim insanları neyi, nasıl araştıracaklarına nasıl karar verirler? Bilim insanlarının çalışmalarını etkileyebileceğini düşündüğünüz tüm faktörleri mümkün olduğunca ayrıntılı bir şekilde yazınız.

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6. Kuşlarla ilgilenen bir insan farklı besinler yiyen yüzlerce farklı kuşu gözlemlemiştir. Bu gözlemlerin sonucunda, benzer besinler yiyen kuşların gagalarının şeklinin de benzer olduğunu fark etmiştir. Örneğin, kabuklu fındık yiyen kuşlar kısa ve sert gagalı, bataklıktan böcek yiyen kuşlar ise uzun ve zayıf gagalıdırlar. Buna dayanarak kuşların gaga şekilleriyle yedikleri besinler arasında bir ilişki olduğu sonucuna varmıştır.

(a) Sizce bu insanın yaptığı araştırma bilimsel midir? Açıklayınız.

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(b) Sizce bu insanın yaptığı araştırma bir deney midir? Açıklayınız.

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7. (a) Sizce veri sözcüğü bilim için ne anlama gelmektedir?

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(b) Veri analizi neleri içermektedir?

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(c) Veri ve kanıt sözcükleri aynı mıdır, yoksa farklı mıdır? Açıklayınız.

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8. (a) Eğer birbirinden bağımsız olarak çalışan farklı bilim insanları, **aynı soruyu** araştırıp, veri toplamak için **aynı yöntemi** kullanırsa hepsi *aynı sonuca* mı varır? Açıklayınız.

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(b) Eğer birbirinden bağımsız olarak çalışan farklı bilim insanları, **aynı soruyu** araştırıp, veri toplamak için **farklı yöntemleri** kullanırsa hepsi *aynı sonuca* mı varır? Açıklayınız.

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(c) Eğer bilim insanları **birlikte çalışıyor** olsaydı, (a) şıkkına vereceğiniz cevap değişir miydi? Açıklayınız.

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(d) Eğer bilim insanları **birlikte çalışıyor** olsaydı, (b) şıkkına vereceğiniz cevap değişir miydi? Açıklayınız.

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APPENDIX D

ÖĞRETİME BAKIŞ AÇISI ANKETİ (EWVS)

	Kesinlikle **Katılmıyorum**	**Katılmıyorum**	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
1. Sınıfımda her bir öğrencinin mutlaka öğrenmesi gereken temel bilgiler olacaktır. Bu bilgilerin bazıları kabul edilmiş bilimsel gerçekler ve bazıları ise herkesin aynı fikirde olduğu kurallar ve kavramlardır. Derslerimde öğreteceğim bilgiler zamanla değişmez ve bu bilgiler benim alanımda uzun yıllar süren çalışmalar sonucunda elde edilmiş önemli gerçekleri ve çıkarımları temsil ederler. Öğrencilerim için önemli olan şey vereceğim bu bilgileri olduğu gibi öğrenmesidir. Öğrencilerimin bu bilgiyi ancak benim gibi bir uzman aracılığıyla öğreneceğine inanıyorum. Çünkü neyi öğrenmeleri gerektiği konusunda onlardan daha iyi deneyime sahibim. Öğrencilerimin öğreteceğim bilgileri kendi kendilerine öğrenmeleri zor olacaktır, benden öğrenmeleri ise hem daha hızlı hem de daha etkili olacaktır. Bundan dolayı, öğrencilere öğrenebilecekleri kadar bilgiyi öğretmek benim sorumluluğumdadır diye düşünüyorum. Benim sınıfımda her öğrencinin genel bir bilgiye sahip olması lazım. Benim görevim de bu genel bilgiyi açık bir şekilde öğrencilere vermek olacaktır.	☐	☐	☐	☐	☐

2. Sınıfımda ki öğrencileri kendi kendilerine öğrenmeleri konusunda yönlendirmem öğrencilerimin bilgileri kendileri için kullanmalarını sağlayacaktır. Fakat öğrencilerin bilgiyi kendi kendilerine öğrenmesi, öğrenmeleri gereken bilgileri anlayarak öğrendikleri anlamına gelmez. Çünkü bilginin öğrenilmesinde öğrencinin yorumunun da önemli olduğunu düşünürüm. Hatta bazı öğrencilerin çıkarımlarının diğer öğrencilerin çıkarımlardan daha iyi olduğuna inanırım. Öğrencilerimin kanıtları nasıl toplayacağını ve değerlendireceğini bilmesi gerekir. Böylece hangi fikrin daha iyi olduğunu ayırt edebilecektir. Bunu yapabilmeleri için gerekli olan bazı yetenekleri öğretebilirim. Fakat gerekli olan bazı yetenekleri de diğer öğrencilerle çalışarak öğrenecekler yada kendi kendilerine öğrenecekler. Böylelikle her öğrenci kendine özgü ve önemli bakış açıları oluşturacaktır. Sınıfımda öğrencilerin ders kaynaklarını bir havuzda toplayabileceği ve en iyi şekilde öğrenebileceği bir ortam hazırlamaya çalışacağım.	☐	☐	☐	☐	☐
3. Bilginin anlaşılmasında çok değişik yolların olduğunu sınıfımdaki öğrencilerin bilmesi gerekir. Bilgiler sürekli değişir, bugün bazı uzmanların gerçek olarak kabul ettikleri şeylere gelecekte şüpheyle bakılabilir. Hatta uzmanlar çalışmaları sonucunda elde ettikleri fikirler hakkında anlaşamasalar bile; belirli bir süre sonra her bir fikrin diğeri kadar iyi olduğunu görülebilir. Bu bağlamda öğrencilerinde kendilerine verilen bilgiyi düşünerek öğrenmeleri gerekir. Aynı zamanda bilimsel otoriteyi ve bilgiyi sorgulaması gerekir. Öğrendiği şeylerin yaşantısını nasıl etkileyeceğini değerlendirmesi gerekir. Bilgiyi akıllıca kullanırlarsa kimse toplum tarafından dışlanmaz. Bilginin öğrenilmesinin kolay olmamasından dolayı öğrencilere neyin önemli olduğunu gerçekten öğretebileceğime inanmıyorum. Çünkü her birinin farklı şeyler bilmesine gerek vardır. Dünyadaki belirsizlikler ve gerçeğin ne olduğu konusundaki farklı görüşler öğrencileri karamsarlığa itse de, öğrenciler kendileri için neyin önemli olduğuna karar verebilmelidir. Kendi yaşamlarını şekillendiren şeyleri dikkate almadırlar. Benim bildiğim ve inandığım şeyler benim öğrencilerimi etkilememelidir. Benim görevim öğrenciler için hiçbir baskı altında kalmadan bilgileri bağımsızca düşünecekleri bir ortam yaratmaktır**.**	☐	☐	☐	☐	☐

APPENDIX E

FEN ÖĞRETİMİNE YÖNELİK İNANÇLAR ANKETİ (STEBI-B)

	Kesinlikle **Katılmıyorum**	**Katılmıyorum**	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
1. Eğer bir çocuk fen konularında her zamankinden daha iyi ise, bunun nedeni çoğunlukla öğretmenin daha fazla çaba harcamasıdır.					
2. Fen konularını öğretmek için sürekli daha iyi yöntemler bulacağımı düşünüyorum.					
3. Ne kadar çok çaba harcasam da fen bilgisi konularını öğretirken yeterince etkili **olamayacağım.**					
4. Fen bilgisi kavramlarını etkili bir şekilde öğretebilmek için gerekli basamakları biliyorum.					
5. Öğrencilerin fen bilgisi dersi notlarının iyiye gitmesi genellikle öğretmenin daha etkili bir öğretim yöntemi kullanmasının sonucudur.					
6. Öğrencilerin fen bilgisi dersinde yaptıkları deneyleri takip etmede yeterince etkili **olamayacağımı** düşünüyorum					
7. Fen bilgisi dersini genellikle etkili bir şekilde **öğretemeyeceğim.**					
8. Öğrencilerin fen bilgisi dersinde başarısız olmasının nedeni büyük bir olasılıkla etkili olmayan fen öğretimidir.					
9. İyi bir öğretimle, öğrencilerin fen bilgisi dersindeki bilgi yetersizliklerinin üstesinden gelinebilir.					
10. Çocukların fen konularındaki başarısının düşük olmasından öğretmen sorumlu **tutulamaz**.					
11. Fen bilgisi dersinde başarısız olan bir öğrencinin başarısının artması genellikle öğretmenin daha fazla ilgi göstermesinin sonucudur.					
12. Etkili bir şekilde öğretecek kadar fen kavramlarından iyi anlıyorum.					

	Kesinlikle **Katılmıyorum**	**Katılmıyorum**	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
13. Fen bilgisi dersini öğretirken öğretmenin daha fazla çaba harcaması, bazı öğrencilerin başarısını çok az oranda değiştirir.					
14. Öğrencilerin fen bilgisi dersindeki başarısından genellikle öğretmen sorumludur.					
15. Öğrencinin fen bilgisi dersindeki başarısı, öğretmenin etkili fen öğretimi ile doğrudan ilgilidir.					
16. Fen bilgisi deneyleriyle ilgili soruları açıklamada zorlanırım.					
17. Öğrencilerin fen bilgisi dersi ile ilgili sorularını genellikle cevaplarım.					
18. Fen dersini öğretmek için gerekli becerilere sahip olacağımdan endişeliyim.					
19. Eğer seçim hakkı verilseydi, okul müdürünü veya müfettişleri beni değerlendirmesi için dersime **çağırmazdım**.					
20. Fen kavramlarını anlamada zorlanan öğrencilerime nasıl yardımcı olacağımı **bilemem.**					
21. Fen bilgisi dersini öğretirken öğrencilerden gelecek soruları her zaman hoş karşılarım.					
22. Öğrencilere fen bilgisi dersini sevdirmek için ne yapmam gerektiğini **bilmiyorum.**					
23. Bir veli çocuğunun fen dersine daha fazla ilgi duyduğunu belirtiyorsa, bunun nedeni büyük olasılıkla öğretmenin dersteki performansıdır.					

APPENDIX F

FEN ÖĞRETİMİNE YÖNELİK TUTUMLAR ÖLÇEĞİ (STAS)

	Kesinlikle **Katılmıyorum**	**Katılmıyorum**	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
1. Fen öğretirken kendimi **rahatsız** hissedeceğim.					
2. İlköğretimde fen konularını öğretmek önemlidir.					
3. Fen dersini yeteri kadar öğretemeyeceğimden **korkuyorum**.					
4. Fen dersini öğretmek çok zaman alır.					
5. Fen öğretirken laboratuvar çalışmaları ve basit aktiviteler yapmaktan zevk alacağım.					
6. Fen dersini anlamada **zor anlar** yaşıyorum.					
7. İlköğretim fen programında yer alan konularda kendimi rahat hissediyorum.					
8. Deneye dayalı fen programında çalışmak ilgimi çekiyor.					
9. Fen öğretmek beni **endişelendiriyor**.					
10. Bilimsel olguları sınıfımda göstermekten korkmam.					
11. Öğretmen olduğumda sınıfta fen öğretmek için **sabırsızlanmıyorum**.					
12. Öğrencilerin fen dersi düzeneklerini kurmalarına yardımcı olmaktan zevk alacağım.					
13. Fen ile ilgili deney düzeneğini kurmak için zaman harcamaktan zevk alırım.					
14. Öğrencilerimin cevaplayamayacağım sorular sormalarından **korkuyorum.**					
15. Fen en az okuma-yazma ve matematik kadar önemlidir.					

	Kesinlikle **Katılmıyorum**	**Katılmıyorum**	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
16. Fen ile ilgili materyaller geliştirmekten hoşlanırım.					
17. Sınıfta fen deneylerinin beklenen sonucu vermemesinden **endişe duyarım.**					
18. Eğer seçme hakkı verilseydi fen, öğretmeyi tercih edeceğim derslerden biri olur.					
19. Öğrencilerimin fen bilgisine karşı ilgilerini artırabileceğimi umuyorum.					
20. Fen dersini öğretmek çok çaba gerektirir.					
21. Öğrenciler fen konularına ilgili değiller.					
22. Feni diğer alanlara entegre etmeyi planlıyorum.					

APPENDIX G

ÜSTBİLİŞSEL FARKINDALIK ENVANTERİ (MAI)

	Her Zaman	Çoğunlukla	Bazen	Nadiren	Hiçbir
1. Hedeflerime ulaşıp ulaşmadığımı düzenli olarak sorgularım.					
2. Bir problemi çözmeden önce farklı alternatifleri göz önüne alırım.					
3. Çalışırken daha önce işe yarayan yöntemleri kullanmaya çalışırım.					
4. Yeni konular öğrenirken daha fazla zamana sahip olmak için öğrenme hızımı ayarlayabilirim.					
5. Zihinsel olarak güçlü ve zayıf yönlerimi bilirim.					
6. Yeni bir ödeve başlamadan önce gerçekten neyi öğrenmem konusunda düşünürüm.					
7. Bir sınavı bitirdiğimde, o sınavda ne kadar iyi yaptığımı bilirim.					
8. Bir ödeve başlamadan önce kendime açık, net ve özel hedefler belirlerim.					
9. Önemli bir bilgiyle karşılaştığımda çalışma hızımı yavaşlatırım.					
10. Ne tür bilgiyi edinmenin önemli olduğunu bilirim.					
11. Bir problemi çözerken her türlü çözüm yolunu göz önüne alıp almadığımı kendime sorarım.					
12. Bilgiyi iyi bir şekilde organize edebilirim.					
13. Bilinçli olarak dikkatimi önemli bir bilgiye odaklayabilirim.					
14. Öğrenirken kullandığım her bir strateji için özel bir amacım vardır.					
15. Bir konu hakkında önceden bilgim varsa en iyi o zaman öğrenirim.					
16. Öğretmenimin benden neyi öğrenmemi istediğimi bilirim.					
17. Öğrendiğim bilgiyi iyi bir şekilde hatırlayabilirim.					
18. Duruma bağlı olarak farklı öğrenme stratejileri kullanabilirim.					

	Her Zaman	**Çoğunlukla**	**Bazen**	**Nadiren**	**Hiçbir**
19. Bir ödevi bitirdikten sonra o ödevi yapmanın daha kolay bir yolu olup olmadığını düşünürüm.					
20. Ne kadar iyi öğrendiğim benim kontrolümdedir.					
21. Konular kavramlar arasındaki ilişkileri anlamama yardımcı olması için düzenli olarak derslerde öğrendiklerimi tekrar ederim.					
22. Bir konuya başlamadan önce, o konu hakkında kendime sorular sorarım.					
23. Bir problemin farklı çözüm yollarını düşünür ve en iyisini seçerim.					
24. Yeni bilgiler edindiğimde, öğrendiklerimin bir özetini yaparım.					
25. Herhangi bir konuyu anlamadığımda başkalarından yardım isterim.					
26. İhtiyaç duyduğumda, öğrenmek için kedimi motive edebilirim.					
27. Çalışırken hangi öğrenme stratejilerini kullandığımı bilirim.					
28. Çalışırken kullandığım stratejilerin ne kadar işe yaradığını değerlendiririm.					
29. Zihinsel yönden güçlü yanlarımı, zayıf yanlarımı telafi etmek için kullanırım.					
30. Yeni bilginin anlamı ve önemine odaklanırım.					
31. Bilgiyi daha anlamlı bir hale getirebilmek için kendi örneklerimi oluştururum.					
32. Bir şeyi ne kadar iyi anladığımı doğru bir şekilde yargılayabilirim.					
33. İşe yarar öğrenme stratejilerini otomatik olarak kullanırım.					
34. Öğrenme sürecinde düzenli olarak belli noktalarda durur ve ne kadar iyi anladığımı kontrol etmek için kendimi sorgularım.					
35. Kullandığım her bir öğrenme stratejisinin ne zaman en fazla yararlı olacağını bilirim.					
36. Çalışmanın sonuna geldiğimde, hedeflerime ne ölçüde ulaştığımı sorgularım.					
37. Öğrenirken, konuları daha iyi anlayabilmek için resimler ya da şekiller çizerim.					
38. Bir problemi çözdükten sonra, her türlü seçeneği göz önüne alıp almadığımı kendime sorarım.					

	Her Zaman	**Çoğunlukla**	**Bazen**	**Nadiren**	**Hiçbir**
39. Yeni bilgiyi kendi cümlelerimle ifade etmeye çalışırım.					
40. Bir konuyu anlayamazsam, kullandığım öğrenme stratejisini değiştiririm.					
41. Öğrenmeme yardımcı olması için bir konunun nasıl organize edildiğine dikkat ederim.					
42. Bir ödeve başlamadan önce ilgili yönergeleri (ne yapmam gerektiğini) dikkatle okurum.					
43. Okuduklarımın daha önceden bildiklerimle ilgili olup olmadığını kendime sorarım.					
44. Kafam karıştığında konu doğrultusundaki varsayımları tekrar gözden geçirim.					
45. Zamanımı hedeflerime en iyi şekilde ulaşabilmek için programlarım.					
46. Bir konuya ilgim olduğunda daha iyi öğrenirim.					
47. Bir konuyu aşama aşama çalışırım.					
48. Konunun ayrıntılarından çok genel anlamına odaklanırım.					
49. Yeni bir konuyu çalışırken ne kadar iyi öğrendiğime dair kendime sorular sorarım.					
50. Bir konuyu çalıştıktan sonra gerektiği kadar öğrenip öğrenmediğimi kendime sorarım.					
51. Yeni bilgi anlaşılır değil ise duru ve üzerinden bir kez daha giderim.					
52. Bir şeyler okurken kafam karıştığında durur ve yeniden okurum.					

APPENDIX H

İNANÇ/DÜNYA GÖRÜŞÜ ŞEMALARI ÖLÇEĞİ (SFWS)

	Kesinlikle **Katılmıyorum**	**Katılmıyorum**	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
1. İnancım veya dünya görüşüm asla değişmez kurallara sahiptir.					
2. İnancımı veya dünya görüşümü oluşturan düşünceler nettir yorum kabul etmez.					
3. İnancımı veya dünya görüşümü oluşturan değerler sabittir, değiştirilemezler.					
4. Eski inançlarımdan veya dünya görüşümden gittikçe koptum.					
5. Galiba zamanla ailemde görüp öğrendiğim inanç veya dünya görüşünden uzaklaştım.					
6. Zamanla önceki inanç veya dünya görüşümden ayrılıp kendime göre yenilerini geliştirdim.					
7. Hiç kimsenin inanç veya dünya görüşü diğerininkinden üstün tutulmamalıdır.					
8. İnanç veya dünya görüşündeki farklılıkların giderilmesi gerekmez çünkü herkesin aynı inanca veya dünya görüşüne sahip olması gerekmez.					
9. Herkesin kendi düşüncesi veya inancı kendine göre doğrudur.					

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Sosyal Bilimler Enstitüsü ☒

Uygulamalı Matematik Enstitüsü ☐

Enformatik Enstitüsü ☐

Deniz Bilimleri Enstitüsü ☐

YAZARIN

Soyadı : Çetinkaya
Adı : Gamze
Bölümü : İlköğretim

TEZİN ADI (İngilizce) : Investigation of the Relationship between Pre-service Science Teachers' Understandings of Nature of Science and Their Personal Characteristics

TEZİN TÜRÜ : Yüksek Lisans ☒ Doktora ☐

1. Tezimin tamamı dünya çapında erişime açılsın ve kaynak gösterilmek şartıyla tezimin bir kısmı veya tamamının fotokopisi alınsın. ☐

2. Tezimin tamamı yalnızca Orta Doğu Teknik Üniversitesi kullanıcılarının erişimine açılsın. (Bu seçenekle tezinizin fotokopisi ya da elektronik kopyası Kütüphane aracılığı ile ODTÜ dışına dağıtılmayacaktır.) ☐

3. Tezim bir (1) yıl süreyle erişime kapalı olsun. (Bu seçenekle tezinizin fotokopisi ya da elektronik kopyası Kütüphane aracılığı ile ODTÜ dışına dağıtılmayacaktır.) ☒

Yazarın imzası .... Tarih ....