The Factors that Mediate Preservice Science Teachers' Understanding of Nature of Science

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Abstract: The purpose of the study is to explore the factors that mediate preservice science teachers' (PSTs) understanding of nature of science (NOS). This study was conducted during the Laboratory Application in Science II course and totally 50 PSTs joined the study voluntarily. The laboratory course was designed under the inquiry-based instruction. The design of the study was qualitative and exploratory in nature. During the semester, reflection papers were collected to understand PSTs' experiences with the intervention every week. At the end of the semester, semi-structured interviews were conducted to determine the impact of the inquiry-based laboratory instruction. All of the data were analyzed at the end of the semester and determined factors that mediate PSTs' NOS understanding. Findings revealed that three main factors; discussions and presentations, using inquiry skills, and doing inquiry-based laboratory activities were determined as factors that lead to development of PSTs NOS understanding. Furthermore, intervention also developed PSTs perspectives about teaching NOS
Key Words: Nature of science, Inquiry based instruction, Science laboratory, Preservice science teachers.

Özet: İlköğretim Fen Bilgisi Öğretmen Adaylarının Bilimin Doğasını Anlamalarına Etki Eden Faktörler. Bu çalışmanın amacı, ilköğretim fen bilgisi öğretmen adaylarının bilimin doğasını anlamalarında hangi faktörlerin etkili olduğunun ortaya çıkarılmasıdır. Bu çalışma Fen Bilgisinde Laboratuar Uygulamaları II dersinde uygulanmış ve toplam 50 fen bilgisi öğretmen adayı çalışmaya gönüllü olarak katılmıştır. Laboratuar dersi araştırmacı-sorgulayıcı yöntemle yürütülmüştür. Bu çalışmada nitel araştırma yöntemi kullanılmıştır. Dönem boyunca her hafta öğretmen adaylarının deneyimlerinin ve gelişimlerinin belirlenmesi için yazılı dokümanlar toplandı. Dönemin sonunda araştırmaya dayalı laboratuar öğretiminin etkisini belirlemek için öğretmen adaylarıyla mülakat yapıldı. Verilerin analizi sonucunda üç önemli faktör; laboratuar ortamındaki tartışmalar ve sunumlar, araştırma becerilerinin kullanılması ve araştırmaya dayalı laboratuar etkinliklerinin yapılması öğretmen adaylarının bilimin doğasına yönelik anlayışlarını geliştiren faktörler olarak belirlenmiştir. Son olarak uygulamalar sonrasında öğretmen adaylarının bilimin doğasının öğretimine yönelik algılarının pozitif yönde değiştiği tespit edilmiştir.
*Anahtar kelimeler:*Bilimin doğası, Araştırma temelli öğretim, Fen laboratuarı, Fen bilgisi öğretmen adayları

Introduction

It is commonly accepted that a scientifically literate student should develop a functional understanding of nature of science (NOS) (Abd-El-Khalick, Bell, & Lederman, 1998; National Science Teachers Association [NSTA], 1982). After the main science education reforms (American Association for the Advancement of Science [AAAS], 1993; National Research Council [NRC], 1996; Ministry of National Education in Turkey [MoNE], 2004; NSTA, 1971), developing scientific literacy was main concern for many countries. Therefore, researchers focused on understanding students' scientific literacy at all levels. Because of uncertainty of definition, science educators used scientific literacy in various ways (Norris & Phillips, 2002). However, understanding of NOS and scientific inquiry (SI) are accepted as important components of scientific literacy. Major education organizations in science education emphasized the importance of students' understanding of NOS and SI (AAAS, 1993; MoNE, 2004; NRC, 1996; NSTA, 1971).

Nature of Science (NOS)

Although science organizations (AAAS, 1990, 1993; MoNE, 2004; NRC, 1996; NSTA, 1971) and science educators aimed to develop conceptions of NOS, there is no one common accepted definition of NOS, and it has been defined in numerous ways (Alters, 1997). Abd-El-Khalick, Bell, and Lederman (1998) defined NOS as "typically, the nature of science has been used to refer to epistemology of science, science a way of knowing, or the values and beliefs inherent to the development of scientific knowledge" (p.418). Some

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aspects of NOS that especially related to K-16 education are unproblematic and there is a consensus about definitions of these NOS aspects (Abd-El-Khalick, 2001; Abd-El-Khalick & Akerson, 2004; Schwartz, Lederman & Crawford, 2004; Smith, Lederman, Bell, McComas, & Clough, 1997). These are (1) The Empirical Nature of Scientific Knowledge; (2) Observations, Inference, and Theoretical Entities in Science; (3) Scientific Theories and Laws; (4) The Theory-Laden Nature of Scientific Knowledge; (5) The Tentative Nature of Scientific Knowledge; (6) The Creative and Imaginative Nature of Scientific Knowledge; and (7) The Social and Cultural Embeddedness of Scientific Knowledge.

Abd-El-Khalick and Lederman (2000) and Lederman (1992) reviewed past studies about understanding of NOS in order to clarify what has been learned from earlier investigations. According to these reviews, most of the research during the 1960s and the 1970s revealed that many science teachers had inadequate NOS conceptions. Similar results were found during the 1980s and the early 1990s studies. After this undesirable result, some researchers focused on ways to improve teachers' NOS conceptions. Studies showed that promoting teachers' NOS conceptions improved students' understanding of NOS (Lederman, 2007).

Scientific Inquiry (SI)

After the 1990s, major reforms in science education included SI as an important part of scientific literacy (NRC, 1996). Schwartz, Lederman, and Crawford (2004) emphasized that SI refers to characteristics of the scientific enterprise and the methods that guide the development of scientific knowledge. In this study, inquiry-based laboratory activities were used to improve PSTs' NOS views. National Science Education Standards (NSES) stressed on inquiry, as a teaching approach. Inquiry involves using scientific knowledge and science process skills (SPS) together (NRC, 2000). Science process skills were categorized as observations, inferences, formulating hypotheses, designing investigations, defining variables, collecting data, and interpreting and communicating results.

Science Laboratory

During the past century, science laboratory courses have been an important part of science education (NRC, 2005). However, it needs more research to represent its values (Domin, 2007) in light of new practices in science education. Roth (1994) stressed that, "although laboratories have long been recognized for their potential to facilitate the learning of science concepts and skills, this potential has yet to be realized" (p. 197). In the present study science laboratory course was used as the context of the study, because it provided a convenient environment to conduct the inquiry-based laboratory activities.

Recently, NRC (2005) presented a report about high school science laboratories. The report focused on some skills need to be developed during laboratory base investigations. These are mastering subject matter, developing scientific reasoning, understanding the complexity and ambiguity of empirical work, cultivating interest in science and learning science, developing teamwork abilities, understanding of NOS, and developing science process skills (NRC, 2005). Some researchers emphasized the importance of actual practicing environment to develop learners' NOS understanding. Akerson et al. (2000) stressed that method courses might not be favorable contexts to develop science teachers' NOS understanding. Moreover, they suggested science content course as "an explicit-reflective approach to NOS instruction embedded in the context of learning science content would not only facilitate developing science teachers' NOS views, but might go a long way in helping teachers translate their understandings into actual classroom practice" (p. 297). This study was conducted in a science laboratory course, which included science contents, such as photosynthesis and evolution.

Context of the Study

In science education literature, there are many studies investigated teachers' practices with teaching NOS (Abd-El-Khalick, Bell, & Lederman, 1998; Abd-El-Khalick & Lederman, 2000; Bartholomev, Osborne, & Ratcliffe, 2004; Lederman, 1999). These studies showed that proper NOS teaching requires not only knowledge of NOS but also qualified teachers and use of accurate teaching methods. This study was conducted in the Laboratory Application in Science II course. The researchers designed inquiry-based activities to improve PSTs' NOS views. Every week PSTs did an activity related to one of the NOS aspects.

In their study, Bartholomew, Osborne, and Ratcliffe (2004) identified five dimensions related to teacher perspectives for teaching nature of science explicitly. These are (1) Teachers' knowledge and understanding of the nature of science, (2) Teacher's conceptions of their own role, (3) Teachers' use of discourse, (4) Teachers' conception of learning goals, and (5) The nature of classroom activities (Bartholomew, Osborne, & Ratcliffe, 2004). These dimensions were addressed in this study as follow:

In the first dimension, Bartholomew, Osborne, and Ratcliffe (2004) defined a line from "Teachers are anxious about their understanding" to "Confident that they have a sufficient understanding of NOS."In the present study, there were two laboratory sections and three instructors taught the course. One of them was the first author of this study and the other two were research assistants. Each instructor had the responsibility of one section together with the researcher. Both research assistants took some courses related to NOS before. They earned their bachelorette degree from elementary science education department. Before teaching the course, every week the researcher and the instructors met three hours to discuss the specific NOS aspect. About first dimension, it can be said that, the instructors were close to "Confident that they have a sufficient understanding of NOS."

In the second dimension, Bartholomew, Osborne, and Ratcliffe (2004) defined a line from "Dispenser of knowledge" to "Facilitator of learning." During the meeting hours with instructors, the researcher and the instructors discussed the laboratory activities and possible questions that would be confronted with during the intervention. The researcher joined the two sections and observed the instructors, and when PSTs ask questions, the instructors generally helped them find answers by themselves, and did not answer students' questions directly. For the second dimension, it can be said that, the instructors were close to "Facilitator of learning."

For the third dimension Bartholomew, Osborne, and Ratcliffe (2004) defined a line from "Closed and authoritative" to "Open and dialogic." This dimension generally was related to the researcher because in both sections, there were discussion parts at the end of the laboratory activities and this part was managed by the researcher. In this part, the researcher asked open questions, not simple confirmatory yes-no questions, and expected deep explanation from PSTs. Moreover, under the control of the researcher, the groups in the laboratory had an opportunity to discuss their results with each other. About third dimension, it can be said that, the researcher was close to "Open and dialogic."

In the fourth dimension, Bartholomew, Osborne, and Ratcliffe (2004) defined a line from "Limited to knowledge gains" to "Includes the development of reasoning skills." In this study, PSTs completed laboratory activity sheets using their science process skills. These laboratory sheets included some questions related to observing, classifying, hypothesizing, experimenting, measuring, etc. While completing the laboratory activities, PSTs used these skills and answered the related questions. For the fourth dimension, the instructors and PSTs fallowed the designated laboratory sheets, therefore, it can be stated that the instructors were close to "Includes the development of reasoning skills."

In the fifth dimension Bartholomew, Osborne, and Ratcliffe (2004) defined a line from "Student activities are contrived and inauthentic" to "Activities are owned by students and are authentic." In the current study every week, PSTs had a nature of science aspect and a blank laboratory sheet including only some directions. In the present study, PSTs were expected to develop their own activities and define their specific directions. Most parts of the laboratory sheets were formed according to PSTs' individual creativity. About the fifth dimension it can be said that the nature of classroom activities were close to "Activities are owned by students and are authentic" because of the structure of the laboratory sheets. Based on all of these dimensions, it can be said that this study was conducted using the explicitly reflective method aiming to develop PSTs' views of NOS.

Nature of Science and Science Process Skills

Science education policies stressed that engaging students in inquiry-based activities is an opportunity to develop their understanding of NOS (NRC, 2000). In order to complete inquiry-based laboratory activities, PSTs need to use their science process skills (SPS). The relationship between scientific inquiry and SPS was described by NRC (1996) as during scientific inquiry students should combine SPS and scientific knowledge to develop their understanding of science. In this study, SPS were classified in two different forms; these are Basic Science Process Skills and Integrated Science Process Skills. Basic SPS consist of observing, inferring, measuring, communicating, and classifying. Integrated SPS comprise of controlling variables, defining operationally, formulating hypotheses, interpreting data, and experimenting. Definitions of basic and integrated science process skills are presented in Table 1.

Table1. *Science Process Skills*

Name of the Science Process Skills	Specific Skills
Observing	the process of gathering information about objects and events using the all appropriate senses
Measuring	quantifying the variables by using variety of instruments and standard or nonstandard units
Classifying	a process that is used by scientists to categorize objects based on their general characteristics
Inferring	developing possible conclusions about observations while using prior knowledge
Communicating	essential to all human endeavors and fundamental to all scientific work
Controlling variable	one of the essential skills for managing the variables of a scientific investigation. Establishing accurate results can be achieved when these variables are identified and controlled carefully
Defining operationally	a skill that describes boundaries of things to be considered in a scientific investigation. For different disciplines the defining operationally can be refer different things
Formulating hypotheses	a statement about a possible relationship in the natural world that might be found through scientific investigations. Hypothesizing should be based on accurate observations or inferences.
Interpreting data	involves some other SPS, for instance, making predictions, inferences, and hypotheses from the data collected in an investigation.
Experimenting	is the process that encloses all of the basic and integrated processes

Source;from (Abruscato, 1995; Carin, Bass & Contant, 2005).

Laboratory Application in Science II included inquiry-based laboratory activities every week. In this course, PSTs had the chance to be actively involved in scientific activities and discussions. Every week PSTs had laboratory sheet, which included activity related to NOS aspect. PSTs completed these laboratory sheets using their SPS. The PSTs completed eight activities. In the Appendix A as an example of the activities, the second activity, which related to observation-inference activity manual, can be seen in Appendix A.

In this study, preservice science teachers' (PSTs) NOS understanding in inquiry learning environment was explored. Specific research question;

What are preservice science teachers' perspectives and experiences related to their learning in the science laboratory course?

(1) What are preservice science teachers' perspectives about factors that might affect their understanding of NOS aspects?

(2) What are preservice science teachers' perspectives about future science teaching?

Methods

In qualitative research the purpose of the study shapes the research designs (Marshall & Rossman, 2006). Therefore, the design of the study was defined as qualitative and exploratory in nature (LeCompte & Priessle, 1993), which provides the importance of contexts and in-depth understandings of PST' perspectives.

Participants

In this study the participants were selected from Elementary Science Education (ESE) program of a public university located in Ankara. In light of recent education reforms the program focuses on contemporary model for educating future science teacher. In their third year, all PSTs in the program are required to enroll in Laboratory Application in Science I for the first semester and Laboratory Application in Science II for the second semester. During this year, these students also enroll in courses directly related to methods of science teaching (e.g., Methods of Teaching I and II, Instructional Technology and Materials

Development, Science Technology and Society, School Experiences). In addition to these courses, the students take pedagogical courses as a requirement of their program (e.g., Classroom Management, Measurement and Assessment, Educational Psychology).

A total of 52 PSTs enrolled in the Laboratory Application in Science II course offered by the program. At the beginning of the course, 50 out of 52 PSTs agreed to join to the study on voluntarily basis. Of the 50 PSTs, 35 were female and 15 were male with a mean age of 21.6 years. All of the PSTs were juniors and had the same science major background. During the semester, this course was taught in two different sections. In the first section PSTs met 4 hours per week (on Tuesdays), the other section met 4 hours per week (on Thursdays). The course hours were the same for both sections from 1:40 pm to 5:30 pm. throughout the course, PSTs worked as a group and selected their group members as they desire. We had six groups per section.

Procedure

During the Laboratory Application in Science II course, each week PSTs were given a laboratory sheet prior to class. Each laboratory sheet started with a reading text about the aspect of NOS that is the focus of that particular week. The reading text introduced PSTs to the particular aspect of NOS prior to each laboratory activity along with a conceptual framework for interpreting scientific investigations. Therefore, this part had an important role for teaching NOS explicitly. Before the inquiry-based laboratory activity every week, PSTs took a pre-quiz included two or three questions related to activities and the aspect of NOS at the beginning of the laboratory section. At the end of the laboratory section, all of the PSTs wrote reflection paper included three questions related to laboratory activities, SPS, and the aspects of NOS. During the laboratory classes, PSTs were engaged in the laboratory activities related to views of NOS during the semester. Each PST in every group was expected to complete her/his laboratory sheets. While completing the sheets PSTs asked questions and discussed their tasks with each other. Furthermore, at the end of the instructor‘s presentation, all groups shared and discussed their results with other groups in the laboratory class. Thus, PSTs joined small-group and whole-class discussions each week.

In this study, the researchers used some laboratory activities, which were developed and/or adopted, related to focus on the aspects of NOS by the researchers. For the focus of this study an activity called as Real Fossils, and Evolution Theories was adapted from Bell (2008) and NAS (1998).

Data Collection Process

In this study, all of the data were collected by means of interviews and PSTs' reflection papers. The data were collected during the Laboratory Application in Science II course. One of the qualitative data sources was interviews with PSTs. At the end of the course, 45 out of 50 PSTs agreed to join the interviews voluntarily. Of these participants, 14 were male and 31 were female. The interviews were conducted to gain deep understanding about PSTs' views on NOS, SPS, and the laboratory activities. During the interviews, a semi-structured interview protocol was used. The interview questions focused on the NOS aspect of the activity. The interview protocol was designed by the first author of this study and two experts on NOS were provided their feedbacks on the protocol. The protocol was finalized when all the issues reached to the resolutions among the experts and the researcher. In the Appendix B as an example of the interview, for the second activity, which related to observation and inference can be seen in Appendix B.

The other data source was PSTs' written reflections. Each week at the end of the laboratory activities all of the PSTs responded to three open-ended questions. These questions were related to that week‘s topic and discussions. Each PST wrote seven reflection papers during the semester. The reflection questions were prepared by the researchers. The reflection papers were collected from the instructors from two sections in the laboratory. These three questions were the same related to each week. In the Appendix A as an example of the reflection paper, for the second activity, it can be seen in Appendix C.

Data Analysis

In order to analyze PSTs' perspectives and experiences related to their understandings in the course the NVivo software program was used to analyze all of the interview and reflection paper data. Transcribed interviews and reflection papers were entered into NVivo software. During the analysis of the data defining statements and assigning codes were validated through extensive discussions with the first author and an intentional scholar, who has experience with qualitative research and conducted quality of research on NOS.

Findings

Data analysis showed that findings about PSTs' perspectives and experiences related to their learning during the course. According to the analyses of the interviews 41 (91 %) PSTs pointed out that their views about NOS were changed at the end of the course. This change can be summarized with below excerpts:

> PST #20: Before this course, I did not know NOS aspects. However, science has its nature from beginning; we were not taught about this subject. In this laboratory, I learned many new things about science. I liked this course.

> PST #33: Before this course I did not know anything about NOS, my views were changed. I knew that scientific knowledge is absolute and it is not affected from creativity. Every week I learned different things about NOS and I was surprised.

> PST #27: Every week we focused one aspect, and my views about NOS were changed. I understand the relation between theory and law, scientists are not objective, scientific knowledge is theory-laden and it is tentative. Before this course, I thought scientists were 100 % certain about what they say, and scientific knowledge absolute and not changeable.

> PST #34: First, I understand NOS in this course. I think NOS is complex, my views about NOS were changed. Sometimes only listening or reading is not enough to understand, thus I prefer laboratory activities to teach NOS. My earlier readings about NOS aspects were meaningful after this laboratory course. Unfortunately, even though throughout my earlier education, I went to really good schools, I had many misconceptions about nature of science. Now, I had chance to change my views thus I am happy. During the laboratory course there were some discussions, these were important for me because I learned many things. Every week we wrote reflection papers about NOS and SPS, I think these papers helped us understand NOS and SPS concepts. This course was the best laboratory course for me and I know this is also true for my many friends. I will be a science teacher I will use these activities.

Three main factors were determined to understand how PST develop their NOS conception. These were; (1) importance of discussion and presentation (explicit discourse about NOS), (2) the importance of using SPS (inquiry skills), and (3) the importance of doing activities (constructivist). From these factors we understood that main characteristics of The Laboratory Application in Science II course were important in shaping the participants' NOS conception. As it was introduced earlier the course was characterized under three issues provided in Table 2. Also in Table 2 how often these characteristics of the course contributed to the participants NOS conception was given.

Table 2. *Factors Affected Development of NOS Conception*

The Course Characteristics	The Participants' Agreement (% of N**)
The Importance of Discussion and Presentation	10* (22,3 %)
The Importance of Using SPS	45 (100 %)
The Importance of Doing Activities	45 (100 %)

- * refers to number of PSTs
- ** refers to the sample of interviews

According to the table, 10 (22,3 %) the PSTs expressed the importance of discussion and presentation to understand NOS aspects during the intervention. For example:

> Part #34: Before this semester, I had some misconceptions, such as theories become laws, and laws cannot be changed. At the end of the activity, there was a presentation in the laboratory, we discussed these concepts, and our misconceptions were changed.

> PST #4: During the activities, we discussed our group members, and at the end, we reached scientific knowledge. In addition, there were presentations after the activities, we learned and connected NOS aspects with these activities.

According to Table 2, all of the PSTs (45) articulated that through the semester using SPS helped develop understanding of NOS aspects. Below, there are three statements from interviews:

> PST #2: I think there are relationships among NOS, SPS and scientific knowledge. While doing experiment we use SPS, using SPS help us to study more systematic, it would be different methods in science. We can reach some results with different methods. We used SPS while conducting activities in the laboratory.

> PST #27: There are strong relationships among scientific knowledge, SPS, and NOS. I figure out that there is a destination we want to reach it, this is scientific knowledge, we used some tools which were SPS and scientific methods, and our way of this journey is NOS.
>
> PST #6: We cannot separate NOS and SPS. Because, in order to do activity we used many SPS in laboratory, and at the end we constructed our scientific knowledge. We should do these to develop science, and findings should be shared by other people to develop science.

Lastly, all of the PSTs (45) stated that doing activity has an important role to develop understanding of NOS aspects. For example:

> PST #31: I think laboratory is more suitable to learn not only NOS aspects but also other science context. Because in laboratory we are active, we do, thus we learn better than traditional class presentations.

> PST #37: Firstly, I liked this course, I read laboratory manual before and we did activities ourselves, thus we could easily understand NOS aspects.

> PST #40: I think student do not understand NOS aspect in class by direct teaching. I remember all of things in the laboratory, because first, we were in conflict then we do activities and we understood. In addition, until the laboratory course I did not set up any experiment, in this course we designed experiments.

After the analysis of interviews, it was found that 37 (82,3 %) preservice science teachers gained some views about their future science and NOS teaching. Although there was not any aim for this subject while planning and conducting this study, the PSTs extended their views about teaching positively. Below, there are some statements from interviews:

> PST #12: I do not think NOS can be taught in class with only lecture. Especially in elementary school, students cannot understand NOS views without laboratory. I think laboratory is important for science courses. I prefer laboratory to teach NOS aspects. Students should do experiments, they should observe directly. My views about NOS were changed during the laboratory course, if I did not join this course, I will graduated from university, I will be a teacher and unfortunately I will teach to my students wrong things about NOS.

> PST #17: When I will be a teacher, I will use laboratory for teaching NOS aspects. Because, I think elementary students could not understand NOS aspect with oral conversations. Students need activities about NOS. In this course, we did activities and we learned better, also we will be teachers, and we will teach NOS like that.

> PST #19: This laboratory is different than other laboratory courses. I think not only NOS but also other science classes should be taught in laboratory. I remember when I was in high school, I only memorized scientific knowledge in class during lectures and I forgot them. I

> learn better in laboratory, because I observe, and I do experiments. I will use some activities from this course, when I will be a science teacher.
>
> PST #25: This laboratory course was different than other laboratories. I think for teaching many aspects [of NOS] laboratory environment is useful, because students can learner better by doing activities. However, some of them [NOS aspects] can be taught in class. I think laboratory should be fruitful, students should like laboratory environments. I will use similar activities to teach NOS aspects to my students in future.
>
> PST #29: I prefer laboratory environment to teach NOS aspects. I think if students do something they can learn better. Science classes should be student centered, students should observe, thus they like science, otherwise science classes will be boring for students. Moreover, during activities students can use and develop their creativities.
>
> PST #7: I absolutely believe that application is very important in science, because by practicing scientific knowledge will be more lasting and fruitful for students. I think science lesson should be taught with inquiry methods in laboratory. Students should do experiments. If students do experiment, they can learn better. Lecture is not enough for learning, because students memorize after lecture.
>
> PST #8: I do not think classroom environment is suitable for science education, I prefer laboratory. Because in class we listen to teachers, take note, and memorize scientific knowledge, after exams we forget all of them. Especially, NOS should be taught in laboratory, because in laboratory, students do experiment, and they can have concrete data, thus they can learn better.

In these quotations, PSTs emphasized that when they will be science teachers, they will prefer to use inquiry-based laboratory activities to teach NOS aspect and other science concepts. The PSTs compared their past learning at middle or high school and they stated difference between inquiry learning and learning through memorization. Generally, PSTs memorized science concepts during their education, but they realized that they did not learn. The PSTs accepted that science concepts should be thought in laboratory environment by using scientific activities. All these expressions revealed that PSTs had a common understanding about effective student learning which was carrying out inquiry-based laboratory activities to teach NOS aspects.

Discussion and Implication

The results showed that PSTs develop their understandings of NOS aspects at the end of the laboratory course. According to the results, PSTs stated three factors, which have role to develop their NOS understandings. These were the importance of discussion and presentation, the importance of SPS, and the importance of doing inquiry-based laboratory activities. The difference between SPS and inquiry was determined by the Standards (NRC, 1996) as “Inquiry is a step beyond ‘science as a process’, in which students learn skills, such as observation, inference, and experimentation. The new vision includes the ‘process of science’ and requires that students combine processes and scientific knowledge as they use scientific reasoning and critical thinking to develop their understanding of science.” (p. 15).

As a first factor, PSTs emphasized the importance of discussions and presentations at the end of the laboratory activities. The laboratory course was designed and the inquiry-based activities were prepared according to explicit-reflective teaching approach. Following the inquiry-based laboratory activities, there were power-point presentations to reflect science educators’ NOS views. Generally, these presentations included summaries of the readings parts. After that, PSTs were engaged in reflective discussions of the target NOS aspects, they shared and discussed their results. Reflective discussions of the target NOS aspects are important, Khishfe and Abd-El-Khalick (2002) conducted an experimental research, and they showed effectiveness of discussions after inquiry-based activities in favoring the experimental group. As a second factor, all of the PSTs stated the importance of using science process skills (SPS) in developing understanding of NOS aspects. Thus it is necessary to emphasize the relation between SPS and NOS because this relation is important for students to internalize science while learning it. On the one hand, scientific processes are skills related to doing experiments, such as observation and inference. On the other hand, NOS refers to the epistemological promises. Bell, Lederman, and Abd-El-Khalick (2000) stated, "[A]n understanding that observations are constrained by our perceptual apparatus and are inherently theory-laden is part of an understanding of the nature of science" (p. 565). In this study, SPS are formed as an important part of explicit-reflective and inquiry-based laboratory activities. While preparing activity sheets many times SPS were used as giving diections, such as 'construct your hypotheses' and 'define your variables' for activities. PSTs expressed that SPS helped them to study more systematical to conclude activities, and to reach scientific knowledge. There are strong relationships among some NOS aspects and some SPS (Khishfe & Abd-El-Khalick, 2002). Researchers noted that, students often conflate SPS with NOS aspects and it is necessary to distinguish both of them (Abd-El-Khalick, Bell, & Lederman, 1998). In this study, these relationships were constructed by PSTs at the end of the course. For instance, observation is one of the important science process skills, also observation is an important way to gain information about natural phenomena, and it is differ from inference. PSTs used their SPS and they improve their understandings of NOS aspects.

In the past, researchers utilized SPS to develop NOS understanding. These attempts were classified as examples of the implicit approach (Abd-El-Khalick & Lederman, 2000). Especially, many of the 1960s and 1970s education programs SPS were accepted an important tool to enhance students' understandings of NOS views. However, most of the studies failed to develop students' NOS views (Gabel, Rubba, & Franz, 1977; Lawson, 1982; Rowe, 1974). For the reason that, the implicit approach assumed that NOS understanding is an 'affective' learning outcome not 'cognitive' (Abd-El-Khalick & Lederman, 2000). Therefore, they did not realize that, in order to improve NOS understanding it needs instructions, which included intentionally and planned NOS aspects. As a third factor, all of the PSTs indicated the importance of doing inquiry-based laboratory activities for understandings of NOS aspects. Using inquiry-based activities was classified as a tool for implicit approach (Abd-El-Khalick & Lederman, 2000). However, in this study inquiry-based laboratory activities and explicit-reflective teaching were integrated. Indeed, according to Inquiry and the National Science Education Standards (NRC, 2000), inquiry-based learning has three dimensions for students. These are learning science concepts and principles, gaining some skills to conduct scientific investigation, and understanding of nature of science. Therefore, using inquiry-based laboratory activities in order to develop NOS views is practical. For example, Schwartz, Lederman, and Abd-El-Khalick (2000) expressed that "For science classroom, explicit instruction attention to, and reflection on nature of science, perhaps in conjunction with, and in direct reference to inquiry activities in which the students are engaged may be the critical pedagogical component required for successful teaching of nature of science through inquiry" (p. 8). In the same way, Abd-El-Khalick and Lederman, (2000) stated that "involving learners in science-based inquiry activities can be more of an explicit approach if the learners were provided with opportunities to reflect on their experiences from within a conceptual framework that explicates some aspects of NOS." (p. 689).

According to reviews about NOS (Abd-El-Khalick & Lederman, 2000; Lederman, 1992; Lederman, 2007) researchers, who believed that developing of NOS views as 'cognitive' learning outcome, and they used explicit approach. Explicit-reflective approach differs from didactic teaching, and this approach emphasized understanding of NOS as cognitive outcome, therefore NOS should be explicitly taught (Khishfe & Abd-El-Khalick, 2002). In this study, NOS aspects were targeted and planned intentionally. In addition, constructivist approach was considered, because this approach helps PSTs construct their understandings of NOS aspects. NOS understandings are cognitive learning outcomes, and they could be best taught using explicit-reflective way as a constructivist approach.

Many research efforts aimed to develop adequate conceptions of NOS for students (Lederman, 2007). Especially some of them focused on teachers' conceptions and their practices in classrooms about NOS (Lederman, 1992). Researchers accepted three assumptions about students' understandings of NOS conceptions in classroom. These are; students' conceptions were significantly related to their teachers' conceptions, teachers transform their conceptions into their practice, and students can gain implicitly adequate NOS views doing inquiry-based activities (Abd-El-Khalick, Bell, & Lederman, 1998). After the research about this topic Abd-El-Khalick, Bell, and Lederman, (1998) concluded that, teachers' conceptions of NOS and their practices in classrooms are more complex. In addition, they indicated that teachers' beliefs about NOS do not automatically influence their practices in classrooms (Abd-El-Khalick, Bell, & Lederman, 1998).

In the findings part aforementioned that there was not any goal about PSTs' future teaching while planning and conducting this study. However, at the end of the course PSTs extended their views about teaching NOS positively. PSTs expressed, they will translate their NOS conceptions in their classrooms, and they will prefer to use explicit reflective and inquiry-based laboratory activities to teach NOS aspect.

Laboratory Application in Science II course did not include any part related to planning and practicing NOS aspects for PSTs. Therefore, there was not any opportunity to asses PSTs' practices about teaching NOS aspects. Further research should explore the effectiveness of NOS instruction on PSTs by examining their real classroom practices.

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Genişletilmiş Özet

Bilimin doğasının anlaşılması bilim okuryazarlığının temel bir yapıtaşı olarak kabul edilir. Bundan dolayı fen alanındaki birçok reform çalışması bilimin doğasının öğrenciler tarafından anlaşılmasını bir hedef olarak belirlemiştir. Bilimin doğasına ait kavramların öğrencilere kazandırılması eğitimciler tarafından amaçlanmasına rağmen tanımı konusunda tam bir uzlaşı yoktur. Bu çalışmada bilimin doğası bilimsel bilginin kendinden kaynaklanan değerleri ve varsayımları içerir ve bilimin bir insan ürünü olması nedeniyle dış faktörlerden etkilendiğini kabul eder. Bu çalışmada bilimsel bilginin yedi temel karakteristik özelliği üzerinde durulmuştur. Bunlar; değişebilir olma, deney temelli olma, sübjektif olma, hayal gücünden ve yaratıcılıktan etkilenme, toplumdan ve kültürden etkilenme ve son ikisi gözlem-çıkarım ve teori-yasa kavramları arasındaki ilişkilerin ortaya konulmasıdır.

Bilimin doğası hakkında geçmiş çalışmaları derleyen araştırmacılar birçok fen öğretmeninin ve öğrencinin bilimin doğasına yönelik kavram yanılgılarının olduğunu ortaya çıkarmıştır. Bilim okuryazarlığının diğer önemli bir yapıtaşı bilimsel araştırma yöntemidir, oda bilimsel bilginin gelişimi için onu yönlendiren metotlar ve bilimsel araştırmanın özelliklerini içerir. Bilimsel süreç becerileri ile bilimsel bilginin birlikte kullanılmasıyla bilimsel araştırma tam olarak uygulanmış olur. Öğrencilerin bilimin doğası hakkında görüşlerini belirlemek ve onları geliştirmek için yapılan çalışmalar genellikle fen öğretimi (metot) derslerinde yapılmıştır. Fen laboratuarı bunun için uygun olduğu halde bu zamana kadar çok kullanılmamıştır. Fen öğretimi için yapılan konferanslarda ve toplantılarda araştırmaya dayalı laboratuar yöntemi ısrarla tavsiye edilmiştir. Bu sayede öğrencilerin hem bilimsel okuryazarlıları hem de bilimim doğasına yönelik anlayışlarının gelişebileceği vurgulanmıştır. Bu çalışmada fen bilgisi laboratuar uygulamaları dersinde yapılmıştır.

Fen eğitimindeki geçmiş çalışmalar göstermiştir ki öğretmen adayları ve öğretmenlerin birçoğu bilimin doğası hakkında kavram yanılgılarına sahipler. Bu ciddi bir problem çünkü eğer öğretmenler kavram yanılgılarına sahiplerse bunları kendi dersleri yoluyla öğrencilerine de geçebilirler. Yapılan çalışmalar göstermiştir ki öğretmenin sınıf içindeki bütün davranışları öğrencilerin öğrenmesinde etkilidir ve öğrencilerin öğrenmeleri öğretmenden bağımsız değildir. Bilimin doğasının amaçlandığı gibi öğretilmesi için öncelikle fen öğretmenlerinin bilimin doğasını doğru bir şekilde anlamış olması gerekmektedir buda onların üniversitedeki eğitimleri boyunca uygun deneyimler sayesinde kazandırılabilir. Fen eğitimindeki önemli reformlardan sonra birçok ülke bilimin doğasına fen müfredatlarında işledi. Bu ülkelerden biride Türkiye'dir, ilköğretim fen bilgisi ders programı yeniden tasarlanıp bilimin doğasına yönelik amaçlar müfredata konuldu. Yeni fen programı kişisel farklılıkları ne olursa olsun bütün öğrenciler için bilim okuryazarlığını hedeflemiştir. Bu bağlamda yeni program bilimin doğasının tam olarak anlaşılmasını ana hedeflerinden biri olarak belirlemiştir. Yapılan araştırmalarda öğrencilerin bilimin doğasına yönelik anlayışlarının gelişmesinde öğretmenlerin çok etili bir faktör olduğu ortaya konulmuştur. Eğer fen öğretmenleri bilimin doğasını anlamaz ve bunu öğretmenin neden önemli olduğunu kabul etmez iseler Türkiye'de oluşturulan bu yeni müfredatı derslerinde uygulamayacaklardır. Eğer öğretmenler bu programı uygulamazsa yeni müfredat değerini ve önemini yitirmiş olacaktır. Bu çalışmanın örneklemi fen bilgisi öğretmen adaylarıdır yanı geleceğin fen bilgisi öğretmenleri.

Bu çalışmanın amacı, ilköğretim fen bilgisi öğretmen adaylarının bilimin doğasını anlamalarında hangi faktörlerin etkili olduğunun ortaya çıkarılmasıdır. Bu çalışma Fen Bilgisinde Laboratuar Uygulamaları II dersinde uygulanmış ve toplam 50 fen bilgisi öğretmen adayı çalışmaya gönüllü olarak katılmıştır. Laboratuar dersi araştırmacı-sorgulayıcı yöntemle yürütülmüştür. Bu çalışmada nitel araştırma yöntemi kullanılmıştır. Dönem boyunca her hafta öğretmen adaylarının deneyimlerinin ve gelişimlerinin belirlenmesi için yazılı dokümanlar toplandı. Dönemin sonunda araştırmaya dayalı laboratuar öğretiminin etkisini belirlemek için öğretmen adaylarıyla mülakat yapıldı. Bu araştırmada fen bilgisi öğretmen adaylarının bilimin doğasına yönelik algılarının gelişmesinde nelerin etkili olduğu ve öğretmen adaylarının algıları ve bakış açıları incelenmiştir. Verilerin analizi sonucunda öğretmen adaylarının bilimin doğasına bakışlarını geliştiren üç temel faktör belirlenmiştir. Bunlar laboratuar dersi boyunca yapılan sunumlar ve tartışmalar, bilimsel süreç becerilerinin kullanılması ve sorgulayıcı metotla etkinliklerin yapılması olarak ortaya konulmuştur.

Verilerin analizi sonucunda üç önemli faktör; laboratuar ortamındaki tartışmalar ve sunumlar, araştırma becerilerinin kullanılması ve araştırmaya dayalı laboratuar etkinliklerinin yapılması öğretmen adaylarının bilimin doğasına yönelik anlayışlarını geliştiren faktörler olarak belirlenmiştir. Son olarak uygulamalar sonrasında öğretmen adaylarının bilimin doğasının öğretimine yönelik algılarının pozitif yönde değiştiği tespit edilmiştir. Fen laboratuarında yapılan tartışmalar ve sunumların önemli olduğu 10 öğretmen adayı tarafından ifade edilmiştir. Bilimsel süreç becerilerinin kullanılması bütün öğretmen adayları tarafından kendi gelişimlerinin bir etkeni olarak görülmüştür. Son olarak öğretmen adaylarının tümü sorgulayıcı yöntemle etkinlik yapmanın bilimin doğasına yönelik anlamalarını geliştirdiğini belirtmişlerdir.

Fen bilgisi öğretmeni adaylarının bu laboratuar dersinin onların gelecekteki fen öğretimleriyle ilişkisine dair görüşleri incelenmiştir. Çalışmanın başında araştırmacının böyle bir amacı olmamasına rağmen verilerin analizi sonunda öğretmen adaylarının fen öğretimine yönelik tutumlarının pozitif şekilde geliştiği belirlenmiştir. Öğretmen adayları ilerde fen öğretmeni olduklarında bilimin doğasını öğretmek için laboratuarda sorgulayıcı araştırma yöntemini kullanacaklarını belirtmişlerdir. Öğretmen adayı geçmişte aldıkları fen dersleriyle bu laboratuar dersini karşılaştırıp bu dersi tercih etmişlerdir. Bu çalışmada öğretmen adaylarının bu laboratuar sersinden sonra deneyimlerine bağlı olarak bilimin doğasının öğretimi hakkında görüşlerinin nasıl değiştiği incelenmiştir. Sonuç olarak öğretmen adaylarının bilimin doğasının öğretimine yönelik pozitif tutum geliştirdikleri belirlenmiştir. Ayrıca çalışmanın sonunda daha önce bilimin doğası konularının fen öğretimi derslerinde vurgulandığı fakat bu çalışmada bunu fen laboratuarında yapmanın öğretmen adaylarının bilimin doğasını anlamalarında etkili olduğu görülmüştür.

APPENDIX A (An Example of NOS Activities)

Laboratory 2

Name	**:**
Surname	**:**
ID Number	**:**

Rationale

Although science associations and science educators aim to develop conceptions of nature of science (NOS), there is no agreement upon a single definition of nature of science. One of the most famous definitions of NOS related to epistemology of science, science a way of knowing, and related to the values and beliefs inherent to the development of scientific knowledge (Abd-el-Khalick, Bell and Lederman 1998). There are some main aspects of NOS. Some of them are scientific knowledge is empirical based, tentative, and scientific knowledge includes observations and inferences (Schwartz, Lederman & Crawford, 2004).
Science process skills (SPS) are thinking skills that scientists use to construct knowledge, think on problems, and formulate the results (Carin, Bass, & Contant, 2005). Scientists make their discoveries by using their science process skills (Abruscato, 1995). SPS are classified in two different forms; Basic and Integrated SPS. Basic SPS consist of observing, inferring, measuring, communicating, classifying, and predicting. Integrated SPS consist of controlling variables, defining operationally, formulating hypotheses, interpreting data, experimenting, formulating models, and presenting information (Brotherton & Preece, 1995).

In this week we will focus second aspect of NOS; Scientific knowledge includes observations and inferences. Observations and inferences are different.

Overview

Objectives

At the end of the laboratory pre service teacher should be able to;

1. Explain the second aspect of NOS; scientific knowledge includes observations and inferences. Observations and inferences are different (specific learning outcomes)
2. Use appropriate basic and integrated science process skills (specific learning outcomes)
3. Design an experiment about the black box (specific learning outcomes)

Black Box. !

Introduction

This laboratory experiment will provide you opportunity to understand the second NOS aspect (Scientific knowledge includes observations and inferences. Observations and inferences are different) and to use necessary basic and integrated SPS.

Preliminary Information
The instructor will demonstrate the Black Box.

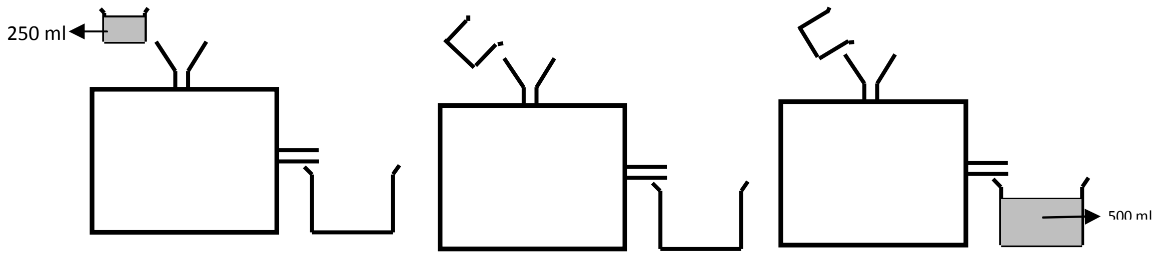

Figure 1 Figure 2 Figure 3

Your research study should include;

1. What is your observation?

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2. State your group purpose

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3. State your group inference about structure in the Black Box?

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4. Determine materials you will use

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5. Write the procedure you will follow

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6. Set up your experimental design

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7. Write your conclusion (your experimental design support your inference or not)

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Appendix B (An example of interview questions)

1- Is there any relationship between scientific knowledge and observation-inference?
2- Can you explain your answer with an example from the second laboratory class?
3- Is there any relationship among nature of science, science process skills, and scientific knowledge?
4- Can you give any example related to science process skills used in the second laboratory class?

Appendix C (An example of reflection paper questions)

By considering the processes that you followed to conduct Black Box experiment please answer the following questions.

1- Explain the aspect of NOS (Scientific knowledge includes observations and inferences. Observations and inferences are different) in your own words. Please relate the aspect of NOS to the experiment that you designed (conducted) in this week.
2- Write the basic and integrated science process skills that you used to conduct the Black Box Experiment.
3- What do you think about the role(s) of SPS to understand the aspect of NOS?