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Teaching Nature of Science by Explicit Approach to the Preservice Elementary Science Teachers[1]

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ABSTRACT: The purpose of this study was to investigate the development of elementary science teachers' understandings of the nature of science as they were taught with an explicit approach. Qualitative research methodologies were used to design the study. Data collection took place during the "Science Teaching Methods" course. Twenty-nine preservice elementary science teachers participated in the study. During the first five weeks of the course Nature of Science (NOS) activities developed by Lederman and Abd-el-Khalick (1998) were administered by the first researcher. Classroom discussions were held after each activity to determine and develop preservice elementary science teachers' perception of the nature of science. The participants' perceptions of the NOS were evaluated with Views of Nature of Science Questionnaire form C (VNOS-C) before and after the intervention. Data was analyzed basing on the interpretivist approach. Results of the study indicated that the majority of the participants held naive views of the targeted NOS aspects at the beginning of the study. Postintervention assessments showed that the participants made substantial gains in their views of some of the targeted aspects of NOS. More substantial gains were evident in the aspects of the subjective, and social and cultural NOS. Less substantial gains were evident in the subject of the difference between the structure and function of scientific theories and laws.
Key words: nature of science, preservice science teacher, explicit approach

ÖZ: Bu çalışmanın amacı fen bilgisi öğretmen adaylarının bilimin doğasına ilişkin algılarını doğrudan yaklaşım yöntemine dayalı bir öğretim süresince incelemektir. Araştırmanın desenlenmesinde nitel araştırma yöntemleri kullanılmıştır. Araştırma için veri toplama süreci Fen Bilgisi Öğretmenliği Programındaki Öğretim Yöntem ve Teknikleri-I dersi kapsamında gerçekleşmiştir. Araştırmaya 29 fen bilgisi öğretmen adayı katılmıştır. Bahsi geçen dersin ilk beş haftalık süresince Lederman ve Abd-el-Khalick (1998) tarafından geliştirilmiş Bilimin Doğası (Nature of Science-NOS) etkinlikleri birinci araştırmacı tarafından uygulanmıştır. Öğretmen adaylarının bilimin doğasına ilişkin algılarını tespit etmek ve geliştirmek üzere her etkinlikten sonra sınıf içi tartışmalar yürütülmüştür. Öğretmen adaylarının bilimin doğasına ilişkin algıları öğretim sürecinin başında ve sonunda Views of Nature of Science Questionnaire-C (VNOS-C) ile değerlendirilmiştir. Veriler yorumlayıcı yaklaşıma göre analiz edilmiştir. Araştırma sonuçları uygulanan öğretim sürecinin başında fen bilgisi öğretmen adaylarının çoğunun bilimin doğasına ilişkin algılarının yetersiz olduğunu göstermiştir. Öğretim sürecinin sonuda ise öğretmen adaylarının bilimin doğasına ilişkin geliştirilmesi hedeflenen algılarında gelişme olduğu gözlenmiştir. Öğretmen adaylarının en fazla gelişme gösterdikleri alanlar bilimin öznel yapısı ve sosyo-kültürel doğası olmuştur. Bilimsel teoriler ve kanunlar arasındaki fark ise öğretmen adayları tarafından en az düzeyde algılanan konudur.
Anahtar Kelimeler: bilimin doğası, fen bilgisi öğretmen adayları, doğrudan yaklaşım.

Introduction

It has been widely accepted that understanding the nature of science (NOS) is a major component of science literacy and an important objective of science education (AAAS, 1990, 1993; Klopfer,

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1969; Millar and Osborne 1998; National Research Council, 1996, National Science Teachers Association, 1992). NOS refers to the epistemology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge (Lederman, 1992). In order to reach the desired level of scientific literacy among individuals, special attention should be paid to the NOS in science education (Driver, Leach, Millar, & Scott, 1996).

Understanding science is more than just facts, laws, and theories. In spite of the significant progress toward characterizing science, there is no single definition for the "nature of science" that fully describes all scientific knowledge and enterprises (Schwartz & Lederman, 2002). While there is no universal conceptualization of the nature of science (Kang, Scharmann, & Noh, 2005; Scharmann & Smith, 2001), and as Suchting (1995) has argued views on the nature of science are likely to evolve as science grows. There does seem to be broad general agreement that the nature of science should be recognised as a human endeavour (the human fallibility has been limited, but not entirely eliminated), tentative (subject to change, as the knowledge is not proven, but simply not falsified), empirical (based on and/or derived from observations of the natural world although these are theory-laden), involving human inference (as distinct from observation), imagination, and creativity (putting forward explanations), and being socially and culturally embedded (Abd-El-Khalick, 2005; Bell & Lederman, 2003; Kang et al., 2005; Lederman, Wade & Bell, 1998; Schwartz, Lederman, & Crawford, 2004).

In the past few decades, it is held that an understanding of the nature of science and of its historical and social context contributes to a more substantive understanding of scientific knowledge, encourages students to take an active interest in science, and generally raises the educational and cultural dimension of science courses (Matthews, 1994). Classical view of science ruled by logical empiricism, which expresses the relationship between scientific claims and empirical proofs, has been drastically challenged by a series philosophers, and principally historians and sociologists of science, who based their arguments on the common view that the development and choice of theories takes place under the deciding influence of concrete world views such as a mechanistic world view for the classical mechanics (Suppe, 1977). This means that the observations, the concepts, and even the empirical data underlying the assessment of the appropriateness of a given theory, are dependent upon and shaped by the world view of the preexisting theories and the related scientific theoretical tradition that has been developed in the scientific community (Giere, 1988 cited in Develaki, 2007).

Changes in the understanding of nature of science have reflected the educational reform movements in recent decades (AAAS, 1993; NRC, 1996). Therefore, the NOS became a critical educational outcome of various science education curriculum in many countries such as Australia, Canada, South Africa, United Kingdom, United States, New Zealand (Lederman, 2007), and Turkey. Many curriculum reform movements focused on the importance of students' (and teachers') understanding of the scientific enterprise itself, the practices of generating scientific knowledge, and the nature of the knowledge produced. Understanding the nature of science enhances students' abilities to critically evaluate scientific claims, benefit from the products of science and technology, as well as participate in the debates surrounding current and future scientific developments (Driver et al, 1996; Lederman, 1992; McComas & Olson, 1998).

In their NOS position statement the National Science Teachers Association (2000) recommends that teachers and students should know that: (a) scientific knowledge is both reliable (one can have confidence in scientific knowledge) and tentative (subject to change in light of new evidence or reconceptualization of prior evidence); (b) no single scientific method exists, but there are shared characteristics of scientific approaches to science, such as scientific explanations being supported by empirical evidence, and are testable against the natural world; (c) creativity plays a role in the development of scientific knowledge; (d) there is a relationship between theories and laws; (e) there is a relationship between observations and inferences; (f) though science strives for objectivity, there is always an element of subjectivity in the development of scientific knowledge; and (g) social and cultural context also play a role in the development of scientific knowledge.

Teachers' knowledge and understanding of NOS is one of the main factors that influence students' knowledge and understanding of it (Abd-El-Khalick, Bell & Lederman, 1998; Abd-El-Khalick & Lederman, 2000; Nott & Wellington, 1996). Research has shown that students, preservice teachers, and in-service teachers hold naïve and inadequate views of the nature of science (Abd-El-Khalick & Lederman, 2000; Cobern, 1989; Driver et al, 1996; Duschl, 1990; Jordan & Duncan, 2009; Lederman, 1992). Teachers who teach science may not hold clear ideas about NOS (Abd-El-Khalick & Lederman, 2000; Abell & Smith, 1994; Lederman, 1992; Moss, Abrans & Robb, 2001; Finson 2002). According to the National Science Education Standards [NSES] (NRC, 1996a), teachers must have ''theoretical and practical knowledge and abilities about science, learning, and science teaching'' (p. 28). Therefore, a goal of science education program is to improve preservice teachers' views of the NOS (Morrison, Raab, & Ingram, 2009).

While there have been many attempts to improve teachers' understanding of NOS, Abd-El-Khalick and Lederman (2000) report that little success has been achieved. Their critical review suggests that approaches that utilise elements from history and philosophy of science and/or direct instruction on NOS were more effective in achieving that end than approaches that utilise science process-skills instruction or non-reflective inquiry-based activities' (p. 694). Therefore, the purpose of this study was to investigate preservice elementary science teachers' understanding of NOS and examine the development of their views on NOS before and after an explicit instruction which employed the elements of history and philosophy of science on NOS.

NOS Related Research

Lederman (2007) summarized the results of initial research on NOS as follows; (a) science teachers do not possess adequate conceptions of NOS, irrespective of the instrument used to assess understandings; (b) techniques to improve teachers' conceptions have met with some success when they have included either historical aspects of scientific knowledge or direct, explicit attention to the nature of science; and (c) academic background variables are not significantly related to teachers' conceptions of nature of science.

In their study of preservice teachers' conception of NOS, Bell, Lederman and Abd-El- Khalick (2000) looked at teachers' translation of knowledge into instructional planning and classroom practice. The subjects were 13 preservice teachers. The teachers' views of NOS were assessed with an open-ended questionnaire before and after teaching. Study results revealed that although all of preservice teachers exhibited adequate understanding of NOS, they did not consistently integrate NOS into instruction in an explicit manner.

Akerson, Abd-El-Khalick and Lederman (2000) were concerned with developing elementary teachers' understandings of NOS and not with the translation of this knowledge into classroom practice. The subjects were 25 undergraduate and 25 graduate preservice elementary teachers enrolled in two seperate methods courses. Before and after the courses teachers' views about the NOS were assessed. The results indicated that explicit attention to NOS was an effective way to improve teachers' understandings of NOS.

Abell, Martini, and George (2001) monitored the views of 11 elementary education majors during a science methods course. The particular context was a Moon investigation in which the authors targeted to assess some aspects of NOS. The authors recognized the importance of being explicit in the teaching of NOS. They also recognized that their students' failure to apply what they learned beyond the learning activities themselves, to the scientific community in general was a consequence of not making an explicit connection between what scientists do and the activities completed in class.

Abd-El-Khalick (2001) used an explicit, reflective approach to teach about NOS in a physics course designed for prospective elementary teachers at the American University of Beirut. Data were collected through pre- and posttests on open-ended surveys about NOS. The author concluded that the explicit, reflective approach to instruction was successful. However, the conclusions were tempered by the authors' concern that understanding of NOS is more easily applied to familiar contexts than to unfamiliar context within science.

Lin and Chen (2002) extended a program designed to improve preservice teachers' understanding of NOS. Sixty-three prospective chemistry teachers participated into the study. The results clearly showed significant improvement of their knowledge of creativity in science, the theory-bound nature of observations, and the function of scientific theories. The authors claimed that helping teachers learn how to use the history of science in science instruction positively influenced the teachers' understandings of the NOS.

Schwartz and Lederman (2002) looked at the improvement of two beginning teachers' understanding of NOS as well as their integration of such understandings into classroom practice. The results showed the depth of NOS understanding, subject matter knowledge, and the perceived relationship between NOS and science subject matter affected the teachers' learning and teaching of NOS. The teacher with more extensive subject matter background, who also held a more well-developed understanding of NOS, was better to address NOS throughout his teaching. This investigation illustrated for the first time that knowledge of subject matter was a mediating factor in the successful teaching of the NOS.

Abd-El- Khalick and Akerson (2004) studied 28 preservice elementary teachers in a science methods course. They investigated the effectiveness of an explicit, reflective instructional approach related to NOS. Study results revealed that participants initially held naive views of NOS; however, over the course of investigation substantial and favorable changes in the preservice teachers'views were evident.

Abd-El- Khalick (2005) conducted a study with 56 undergraduate and graduate preservice secondary science teachers enrolled in a two-course sequence of science methods. Participants received explicit, reflective NOS instruction. Ten of the participants also enrolled in a graduate philosophy of science course. The Views of Nature of Science Questionnaire form C (VNOS-C) was used to assess understandings of NOS at the beginning and the end of the investigation. Results indicated that the students who were enrolled in the philosophy of science course developed more in-depth understandings of NOS than those just enrolled in the science methods course.

Scharmann, Smith, James, and Jensen (2005) used an explicit, reflective approach to teaching NOS within the context of a secondary teaching methods course. Nineteen preservice teachers were subjects. Overall, the authors decided that the instructional approach was successful and supported the emerging literature on the value of an explicit approach to teaching NOS.

In the light of previous studies, an effective instructional approach to teaching nature of science to preservice elementary science teachers should include elements of history and philosophy science, explicity address the aspect of nature of science, and connect to scientific work of scientist to the subjects' experience during the instructional activities. Therefore, this study was designed as an explicit instruction of nature of science including history and philosopgy of science and supported by rich classroom discussions about preservice science teachers' experiences in the classroom.

Methodology

This study was conducted with an interpretivist qualitative approach (Strauss & Corbin, 1990; Şimşek & Yıldırım, 2006) and focused on the preservice elementary science teachers' understandings of NOS. Data collection consisted of various qualitative data collection methods such as an open-ended questionnaire, supported with interviews, video recorded classroom discussions guided by the researchers, and participants' written reports and drawings of some activities. The VNOS-C open-ended questionnaire, combined with interviews (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002), were used to assess preservice teachers' views of NOS before and after the intervention to determine change in conceptions. Data for the study were collected through a five week period in a science methods course.

Participants

Participants were 29 (26 female and 3 male) preservice elementary science teachers who enrolled in a science methods course as part of their undergraduate elementary science education program. Participants' ages ranged between 20 and 23. All the participants completed their required science content course during their first and second year in the department. The course in which the present study was carried out was a core course for all the teacher candidates in the department of elementary science education in a mid-sized Turkish university.

Context of the Study

The 'Elementary Science Methods Course' aimed to introduce contemporary approaches in science teaching to the teacher candidates along with helping them getting familiar with the standards and learning outcomes of elementary science curriculum. Elementary science curriculum in Turkey has been renewed in 2004 in the light of a constructivist approach and included NOS tenets as integrated into the various learning units. The Elementary Science Methods Course provided opportunities to teacher candidates to design learning environments based on constructivist principles. In order to provide a chance to experience various constructivist learning environments to the teacher candidates, the course content was organized with an introductory section including NOS activities developed by Lederman and Abd-El-Khalick (1998).

The first author taught the first five week period of the science methods course with emphasis on nature of science during the spring semester of 2010. The class was held weekly in 3-hour blocks. The rest of the course was organized to help preservice elementary science teachers gain a perspective on contemporary science teaching philosophy and variety of science teaching methods. The course content also included the standards related to nature of science in the National Science Education program for elementary schools.

Data Collection and Instruments

The open ended questionnaire, the VNOS-C, developed and validated by Abd-El-Khalick and Lederman (1998) and revised by Lederman, Abd-El Khalick, Bell, and Schwartz, (2002) was used to assess the preservice teachers' views of nature of science. VNOS-C included questions that address the various aspects of NOS and also aimed to assess views of the social and cultural embeddedness of science and the existence of a universal scientific method. In adapting the instrument to Turkish language, two academics specialized in English language independently translated the scale into Turkish, compared the two Turkish versions and finally got one version out of them. The Turkish version of the instrument was again translated into English by two different experts, the versions were compared once more and the instrument took its final form.

All the participants were answered the questionnaire before and after the five weeks of the intervention. In addition, a total of 6 participants were selected for interview after the completion of the course. Selection of the participants for the interview was purposeful. The criteria was selecting the participants was the extent of development in their NOS views. Interview participants included the ones who had shown the least and the most development in their views. During the interviews, the selected participants were provided with their pre and post interventionquestionnaires and asked to read, explain, and justify their answers. In addition, some clarifying questions were asked in order to get a better understanding of their views on NOS and the changes, if any, they had after the NOS intervention. All interviews lasted between 30 (or 45) minutes, were recorded and transcribed for analysis. Moreover, students written reports related to some activities (Tell a Story) and their drawings (Draw a Scientist, a Veterinarian, and a Teacher) were also used a source of data.

Intervention

The intervention took place during the first five weeks of the science methods course. The instructor facilitated nine different activities addressed the seven targeted aspects of NOS. Along with the activities developed by Lederman and Abd-El-Khalick (1998), a historical movie about Galileo and his scientific work was shown in the classroom to engage students in discussion about how science works. The activities were selected based on the targeted NOS aspects, which were the focus of the research. Each activity was conducted in a way that participants worked in small groups and shared their ideas during the discussions. The researchers guided the activities and acted as facilitators for the discussions. Probing questions were used to help participants to make the connections between activities and targeted NOS aspect. The activities that addressed differences between observation and inferences and empirical, creative, imaginative, and tentative nature of scientific knowledge were Tricky Tracks, Tell a Story, and The Whole Picture. These three activities were used to introduce NOS to the preservice teachers. The main purposes of these activities were to help preservice teachers to distinguish between *observation and inference*. During the activities the researchers asked questions such as 'how can you relate what have you done in this activity with the work of scientisits?', 'what are your observations and inferences about gravity or a natural phenomenon? ', or 'can you provide an example from scientific works which includes observations and inferences?'. Therefore, researchers aimed to help preservice teachers to realize that based on the *same* set of evidence (observations, or data), several answers to the same question may be equally valid (Lederman & Abd-el Khalick, 1998). Four activities, similar in nature, were used to introduce participants to the theory-ladenness and the social and cultural embeddedness of science. Those were Young or Old?, Fisherman or Bird?, Eskimo or Native American?, and Rabbit or Duck?. The main purpose of these activities was to address the common understanding of science and scientists being 'objective'. It is believed that scientists conduct `objective' observations, reach `objective' conclusions, and evaluate new evidence, `objectively' (Lederman & Abd-el Khalick, 1998). However, It is often the case that scientists provide different interpretations of the same set of evidence, come up with different hypotheses to explain the same evidence and defend those interpretations, explanations or hypotheses. In order to help participant reach the conclusion that indicates the theory-laden and the social and cultural embedded nature of science, the researchers used probing questions suggested by Lederman and Abd-el Khalick (1998) such as "How come we are looking at the very same drawing and seeing two different things?", "How can it be that some of us see only one face and not the other?" and "Is it possible that some scientists may look at the same piece of evidence or set of data and see different things?". Disscussions following these questions included ideas such as scientists' training, previous knowledge, and experiences may direct him/her to `see' a certain set of evidence from a certain perspective.

Two black box activities, The Tube and the Water Machine, were also conducted to enhance participants' perception of nature of science about the aspects addressed by the previously mentioned activities. These activities addressed all targeted aspect of nature of science. Those were;

- The distinction between observation and inference.
- That scientific knowledge is partly a product of human inference, imagination, and creativity.
- That scientific knowledge is, eventually, empirically based.
- That scientific knowledge (both theories and laws) is tentative and subject to change.
- That scientific models (e.g., atom, gene) are not copies of reality. Rather, these models are theoretical entities used to explain natural phenomena. (Lederman & Abd-el Khalick, 1998).

In addition to the activities, a movie about life and works of Galileo Galilei was showed in the classroom. The movie provided opportunities for classroom disccusion about the social and cultural embededness of science. Nature of science related examples from the life and works of Galileo, especially his claims about the the earth and all planets revolving around the sun, and the church's response to his work, were presented as examples of the relationship among science, culture, religion, and society. Table 1 provides a schedule of the activities conducted each week during the invervention.

Table 1. *Schedule of the Activities*

Weeks	Activities
1st Week	Tricky Tracks, Tell a Story, The Whole Picture
2nd Week	Young or Old, Fisherman and Bird, Eskimo and Native American, Rabbit or Duck
3rd Week	The Tube, The Water Machine
4th Week	Life of Galileo Galilei (Movie)
5th Week	Summary and overall discussion about activities

Previous studies showed that using de-contextualized nature of science activities provide participants opportunities to grasp the main framework for the nature of science (Akerson, Abd-El-Khalick, & Lederman, 2000; Abd-El-Khalick, 2001; Khishfe & Abd-El-Khalick 2002; Schwartz & Lederman 2002, Abd-El-Khalick, 2005). Therefore, all of the activities were selected as generic in nature. During the activities, the researchers followed an explicit approach. Classroom discussions were carried out during and after each activity to reveal and enhance students' views of nature of science. Discussions were purposefully driven to explicitly point out aspects of NOS that the activities emphasized. Participants were encouraged to explain their ideas of science, their view of scientists, scientific knowledge, and the way science is conducted in regard to the targeted aspect of nature of science (Lederman & Abd-El-Khalick, 1998). Figure 1 summarizes the process of data collection and analyses.

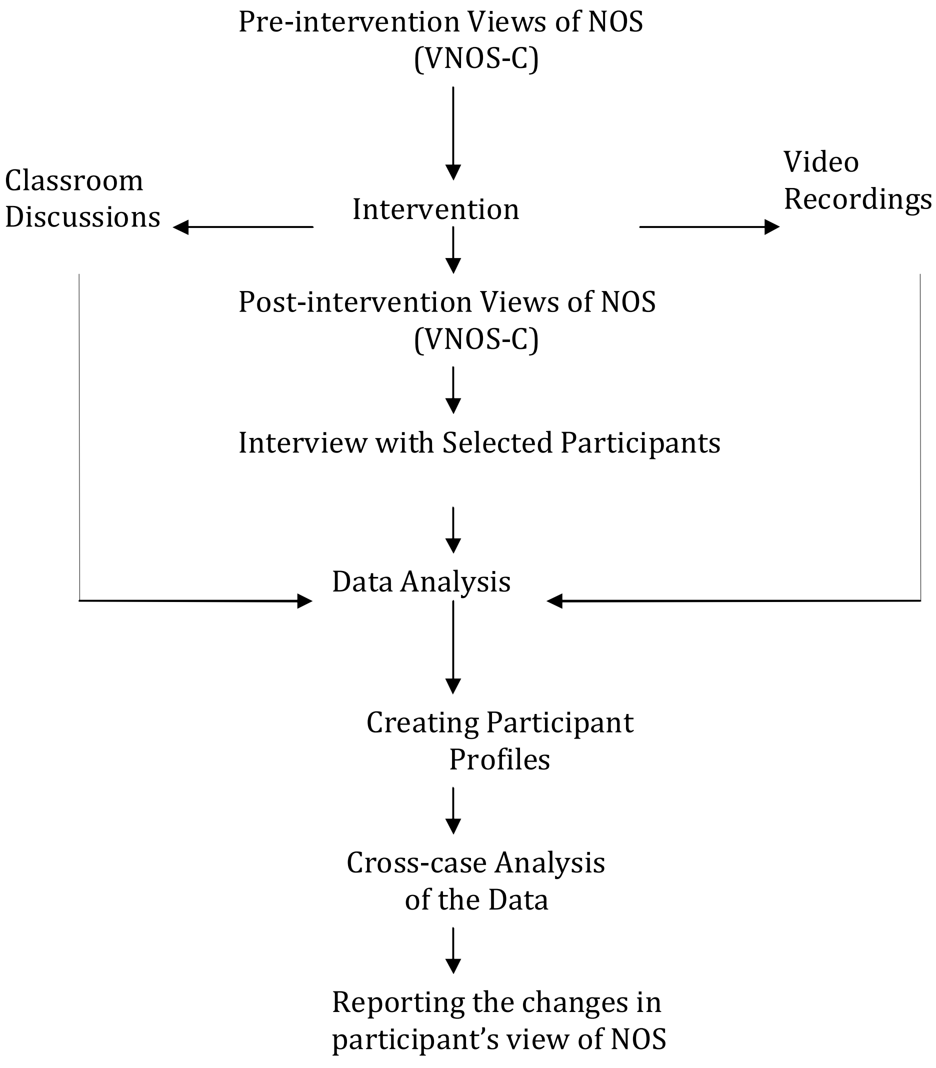

Figure 1. Process of data collection and analyses.

Data Analyses

Data from Views of Nature of Science (VNOS-C) questionnaire and the video taped classroom discussions were transcribed and analyzed by both of the researchers. The qualitative data analysis was interpretive in nature and focused on the meaning that participants gave to the aspects of NOS. Each participant was considered as a separate case, and the nature of science profiles for each participant were established. Pre- and post-intervention profiles of each participant were compared to determine the development in participants' views of nature of science. In order to create participant profiles Khishfe and Abd-el Khalick (2002)'s analysis approach was used which was structured based on the statements provided by Lederman et al (2002), Khisfe and Abd-el Khalick (2002), and McComas and Olson (1998). The qualitative data have been partly provided by answers to follow up interviews as well. The purpose of making interviews after VNOS-C application was to increase validity of the answers to VNOS-C questionnaire. Researchers have analyzed the answers to VNOS-C questionnaires for pre and post intervention. Participants' responses were categorized as 'Naive'and 'Informed'. The criteria for the categorization were whether or not a participant's view is appropriate to the targeted NOS aspects. Participants' answers were categorized as informed, if they provided evidence of an appropriate view of the targeted aspect of NOS. Therefore, participants were not categorized as naive or informed but their views of separate targeted NOS aspects were.

During the process of generating participant profiles, the targeted NOS aspects were used as themes to create categories. In order to establish reliability of the data analysis process, each category then was used to accumulate the data from the participants' answers in the questionnaire under the same themes. This process was repeated for both for pre-intervention and post-intervention questionnaires. The agreement between the two researchers has been found as 77% for pre questionnaire answers and 89% for post questionnaire answers.

Findings

Findings of the study will be presented in the order of application of questionnaire and the intervention. Therefore, preservice elementary science teachers' understanding of NOS before the intervention, findings that reveal the change in participants' NOS concept during the classroom discussions and findings regarding their understanding after the intervention will be discussed in the same order. Table 2 shows the difference between pre and post intervention views of preservice elementary science teachers about the targetted NOS aspects.

Table 2. *Preservice Elementary Science Teachers' Pre and Post Intruction Views of NOS*

	Pre-İntervention		***Post-İntervention***	
NOS Aspects	*Naive*	*Informed*	*Naive*	*Informed*
Observation vs. Inference	*24*	*5*	*9*	*20*
Tentativen ess	*21*	*8*	*4*	*24*
Theories vs.Laws	*29*	*0*	*29*	*0*
Subjectivity	*21*	*8*	*3*	*26*
Social and Cultural NOS	*24*	*5*	*5*	*24*
Creativity and Imagination	*11*	*18*	*1*	*28*

Pre-intervention NOS Views

Participants' views of NOS were identified as inadequate in all of the NOS aspects targeted in this study. Most participants' pre-intervention views of the distinction between observation and inference and the relationship between theories and laws, as well as their views of the tentative, subjective, and social and cultural NOS were categorized as naive. Findings indicated that most of the participants showed naive views of five of six target aspect of NOS. Regarding the differences between observations and inferences, only 5 participants showed informed views while 24 participants held naïve views. It was evident in their responses to the question about how certain are scientists about the structure of the atom and the evidence used to derive this structure that participants lack understanding of the difference between observation and inference. Participants stated that in order to construct the model of atom, scientists used high powered microscopes and literally observed the atom:

> There have been various experiments to examine the structure of the atom. The atoms were investigated under microscope. Based on the observations made by microscope, the concepts of proton, neutron, and electron were developed (pre-questionaire 2)

> The atom is a whole that holds everything together (proton and neutron) and the matter is constructed by atoms which are connected to each other with electrons. Those can be seen by microscopes (pre-questionaire 20).

Preservice elementary science teachers believed that the structure of the atom was directly observable through microscopes. Therefore, it can be concluded that preservice teachers hold the notion that seeing was knowing. They failed to recognize the difference between observation and inference.

Findings from the pre-questionaire revealed that only eight participant showed adequate views about the tentative nature of science. The rest of the participants (21) held naive views about the tentativeness of scientific knowledge. Although participants with naive views indicated that theories can change, their beliefs that theories turn into laws after proven and accepted by the whole scientific community pointed out that they do not have sufficient understanding of either about the tentative nature of science or the function of and relationship between scientific theories and laws:

> Theories become laws after accepted by everybody. Scientific information other than laws can change, theories can change too. Theories can change proven otherwise or there is evidence showing their shortcomings (pre-questionaire 7).

> I believe scientific theories do not change. Theories are products of long term studies. In order for a hypothesis to become a theory, it should be (proven) over and over again for so long and should give the same results every time. Theories do not change but the developments in science and technology can provide explanation to some phenomenon and build a relationship to theory (pre-questionaire 6).

Additionally, participants' answers to the question of the difference between the scientific theories and laws showed that none of the participants has an adequate understanding of the function of and relationship between scientific theories and laws. The most common future mentioned by the participants was the lack of consensus on scientific theories among scientists:

> Scientific theory: Needed to be proven (Theory of Evolution)
> Scientific Law: Proved and accepted by everyone (Newton' law of gravitation) (pre-questionaire 11)

> Scientific theories become scientific laws after accepted by everyone. For example theory of evolution is accepted by some people and not accepted by others; therefore it is still a theory. Scientific theory means it does not have validity yet, just a theory. But scientific law is accepted and has validity (pre-questionaire 15)

About the subjectivity in science, most of the participants (21) failed to realize that the scientists' social and cultural background, their training, theoretical commitments, assumption, preferences and prejudices play a role in the production of scientific work. Although participants mentioned differences in scientists' views may result in differences in outcomes, they are not able to attribute these differences to the social and cultural differences in which science is done. A common point in participants' answers to the question about the reasons for disagreement among scientists who work on the same subject with the same information was the difference in viewpoint:

> Because, not everyone's view is the same. People may have different views. Since there is not a fully proven truth there can be two different results (pre-questionaire 4).

In addition, participants believed that science is the work of excavating the truth and not influenced by the social and cultural norms of the society in which it is produced. It is worth to note that all participants (24) who have inadequate views on the social and cultural embeddedness of science started their answer by stating that science is universal.

> Science is universal. Science is the effort to create a connection with truth. It is not influenced by the cultural norms of the society. It is accepted by everyone. (pre-questionaire 9)
>
> Science is universal. Since there is only one truth, it does not change based on whereit is same everywhere (pre-questionaire 10)
>
> Science is universal. So, it is not inflenced by national, cultural and social variables. Science is the same everywhere. If something is proven it is accepted by everyone. This has nothing to do with social and cultural norms. For example, most science is done in western countries we accept those and even use them. (pre-questionaire 11)

As evident in the statements above most of the participants believe that science is about absolute truth, and it is universal. These results indicate that participants hold a more traditional view about science. They also fail to recognize the difference between the universality of factual scientific knowledge and process of doing science itself. Participants indicated this view by stating that "water always boil at 100 °C at sea level everywhere in the world".

About the creative and imaginative nature of science, more than half of the participants (18) showed adequate understanding. Participants who demonstrated adequate understandings of the role of human inference, imagination, and creativity in generating scientific claims indicated that creativity and imagination take part in every step of the scientific process.

> Yes, they use their creativity and imagination. It can be in every phase. Their creativity and imagination help them bring a different dimension to the phenomenon. They approach the subject with a different point of view. This improves the science (pre-questionaire14).
>
> *I think* creativity and imagination is necessary for probing new questions and inventions. But imagination can not be used for building knowledge…Because everyone's creativity and

imagination is different. For certainty there should be observation, data collection, hypothesis and theories. It can not change from one person to another. (pre-questionaire 28)

Pre-questionnaire results showed that in general any participants of the study do not have adequate understanding on all of the targeted NOS aspects. Although most of the participant pre-service science teachers provided informed views of NOS in some aspects, 5 of the participants presented naive views on all of the targeted aspects of NOS.

Classroom Discussions

The first session of NOS intervention started with the activity called "Tricky Tracks". Researchers used open ended questions to excavate preservice teachers' understandings of nature of science as well as to create awareness about the inconsistency between their conceptions and the contemporary understandings of NOS. During classroom discussions preservice teachers presented supportive ideas to 'naive' statements about empirical nature of science which most of them stated on pre-intervention questionnaire. Following diologs were occurred during the activity:

R1: Ok, what do I need for my statement to be more reliable?
S8: These are abstract statements, they need to be proved.
R1: What if I say these are my concrete data?
S8: They can not be concrete.
S21: Maybe we can say that, normally there should be an experimental group and a control group in scientific works. For example, we observe that if some factors change when one factor is fixed. So, there should be something like that (a control group and an experimental group) for us to make an inference.
R1: Are you saying that the controlled experiments are always neccessary when doing science?
S21: Yes, they are necessary.
R1: Controlled experiments are neccesary in science? (Approvals from the students). Can we always conduct controlled experiments? ......No, we cannot.
S23: We can do controlled experiments in sciences but may be not in social sciences.

The above conversation indicates that preservice elementary science teachers' perception of science is limited to physical sciences. They stated that scientific knowledge can only be produced as long as the data were collected with quantitative methods of data collection. They realized the role and function of controlled experiments in science. However, they lack understanding about various ways of doing science other than 'scientific method'.

Following sections of the classroom discussions provide examples of how teacher candidates commented about the tentative nature of the scientific knowledge based on the availibility of new data in regard with the Tricky Tracks activity. They have also indicated that creativity and imagination plays a role in scientific work, when they have discussed the different interpretations of the "data" provided during the activity.

R1: When you think about this process, can you say that the number of your observations has increased?
Class: Yes
R1: What have you learned based on your observations? Has your opinion changed between the first obervation and the last observation?

Class: Of course, it is clearer now.
S 14: Our opinions get closer to each other.
S15: We were looking at it from a perspective, now we are looking at it from a different perspective.
R2: Ok, if you try to make connection with scientific processes, how do you think scientific processes work? How do you relate what you have done here with the scientific work?
S 16: We see that we are at a different point than where we have started.
R 1: What makes it possible?
S 2: We tried to reach the whole by connecting the pieces.
S 18: We have interpreted as we can observe. Science is like that too, there are some parts we cannot observe. We just interpreted without having all of the parts. When we have all the parts our ideas became closer to each other.

During the second session of the intervention, students worked on an activity called "Tell a Story" in which they were asked to write a story based on a group of pictures without an order. Each group wrote a story and shared it with the whole class at the end of the session. The purpose of this activity was to help preservice teachers to realize scientists' training and disciplinary backgrounds, their theoretical commitments, philosophical assumptions, prejudices and preferences, as well as the social and cultural contexts in which they live do influence their work.

S 7: For example, we used our previous knowledge when we wrote our stories, scientists work the same way.
R 1: They use their old or previous knowledge. What was your previous knowledge when you wrote your stories?
S2: We needed to see the pictures to distinguish which one is a pig, wolf or a fox.
R1: You needed to know the concept of "fox" so that you can say that the animal you see in the pictures with four legs and furr is either a fox or a wolf. I also heard things like "devilish wolf", "grandmother", "labor pig",or "cute piggies"…What can you say about these staments? Observation or inference?
S 2: Devilish wolf is an inference.
R2: How do you relate what you did in this activity to work of scientists? How do scientists work?
S6: They use their previous knowledge. For example, if a scientist worked on the same subject and could not reach to a conclusion, another scientist can work on the same subject and conclude it by bringing a different view point. In this activity we used our previous knowledge about a fairy tale to create a story with the pictures you gave us. Some of our friends wrote very different stories that have nothing to do with Little Red Riding Hood. So, two scientists may have two different viewpoints.
S 3: We have the same data but our background, imagination and point of views are different

The above conversation present examples of how participants' views were shaped based on the activity. They were able to recognize the social and cultural embededness of science by reflecting on their own experiences with the activity. Classroom disccussions provided opportunities for researchers to follow the changes in preservice elementary science teachers' view before, during, and after the activities. During the process preservice teachers presented supportive statements, which indicated their VNOS views were chancing.

Post-Intervention NOS Views

Results of the post-questionnaire data analysis showed that preservice science teachers improved their understanding of NOS with all aspects except the functions of and relationship between scientific theories and laws. Before the intervention there were only 5 participants who showed informed views on the difference between observation and inference; however, the number of participants who showed informed views on the same aspect of NOS increased to 20 following the intervention.

> When we conduct scientific research we do not have the chance of direct accesses to things we work on. We use our previous knowledge. For example, we say the earth has layers but we can not directly observe or investigate these layers. We use models to make investigation. Scientists were not able to see the atoms at first. They reached some results by using the data from the experiments and generating patterns (postquestionaire 21).

About the tentative nature of science, the number of informed views increased from 8 to 25 after the intervention.

> When a new result has been reached or a new case has occurred the existing knowledge may change. For example, I read news on the internet that saying new evidence which can change the history of humanity and the theory of evolution has been found. These findings can change some parts of the theory of evolution. Science is something like that; it can change (post-questionaire 13).

While at the beginning of the study, only 8 participants' views on subjectivity of science showed evidence of adequacy, after the intervention, 26 participants presented informed views.

> Although the data is the same, different point of views may result in different outcomes. If two different people look at the same data thing they may bring different interpretations or come up with different interferences. (post-questionnaire 16)

Social and cultural embeddedness of science was another aspect of NOS that participants showed mostly (24 participants) naive views. However, at the end of the study 24 participants showed adequate views on the social and cultural embeddedness of science.

> Scientists are influenced by the culture they live in, their own religious beliefs. They are also influenced by other scientists who have different beliefs and philosophical views. And they reflect these influences to their works (post-questionnaire 14)

The role of creativity and imagination in science was another targeted aspect of the NOS on which participants showed better understanding after the intervention than they had before. At the end of the study, the number of participants who have informed views increased from 18 to 28.

> Scientists use their creativity and imagination. That is why there are different theories and studies on the same subject. For example, atomic theories, there are more than one theory in order to explain the structure of the atom. When a theory is limited to explain some aspect the other may work. (on the same data)….different inferences may result in different theories. At this point scientists' imagination and creativity may play a role. Scientists usually use their imagination and creativity after they gathered their data to reach a conclusion. Imagination and creativity are also important at the stages of planning and designing.

Discussion and Conclusion

Various approaches have been undertaken to enhance teachers' views of several important aspects of NOS with differing levels of success (Abd-El-Khalick & Lederman, 2000; Abd-El-Khalick & Akerson, 2009). Results of the present study indicated consistency with previous research studies on science teachers' views of NOS (e.g., Abd-El-Khalick & BouJaoude, 1997;

Abd-El-Khalick, 1998; Aguirere, Haggerty, & Linder, 1990; Bloom, 1989; Carey & Stauss, 1968, 1970; King,1991; Pomeroy, 1993), that is participant preservice elementary teachers held naive views of many of the investigated aspects of NOS at the beginning of the study.

Akerson, Abd-El-Khalick, and Lederman (2000) showed that explicit reflective activity-based approach to NOS instruction undertaken within the context of the investigated science methods course was effective in enhancing participant preservice elementary teachers' views. Their study results showed that participants made substantial gains in their views of some of the target NOS aspects. Participants made relatively more gains in their understandings of the tentative, and creative and imaginative NOS, as well as the distinction between observation and inference. Less substantial gains were evident in the case of the subjective, and social and cultural NOS. The results of the present study also support the effectiveness of explicit NOS instruction. However, the current study indicates differences in terms of participant preservice elementary science teachers'gains about targeted NOS aspects. The most improvement was evident in the change of the participants' views on the social and cultural embeddeness of NOS. On the other hand, the functions of and relationship between theories and laws was not substantially understood by the participants.

The results revealed that there was no change in participants' views on the function of and the relationship between scientific theories and laws. Consistent with prior research findings (see Abd-El-Khalick and Lederman 2000; Abd-El-Khalick, 2005), all of the participant preservice teachers ascribed a hierarchical view of the relationship between scientific theories and laws whereby theories become laws when 'proven true.' While almost all students indicated that scientific theories do change with the advent of new evidence, and technological development, a large majority believed that laws are 'sure in all cases' or 'facts' and not amenable to change because they are 'proven to be true.' Instead, many participants ascribed to the term 'scientific theory' meanings associated with the vernacular sense of the word 'theory' as 'someone's guess of what is going on.' Previous research studies showed that science teachers had dogmatic assumptions about the structure and function of scientific theories and laws (Oginniyi, 1982; Erdoğan, Çakıroğlu, & Tekkaya, 2007; Pomeroy, 1993) which also influced the teachers' practice and instruction in the classroom (Zeidler & Lederman, 1989; Gallagher, 1992; Waters-Adams, 2006).

Data analysis also indicated some problems regarding the nature of VNOS-C questionnaire. Questions about how scientists were certain about the notion of species were not fully understood by the participants. In their written answers to the pre and post questionnaire, participants tended to give the scientific definiton of the notion of species instead of referring to science as a human activity, and the notion of species is created by humans. The participants ignored the fact that the framework with which scientists work may change, and an organism can be categorized under a different species or sub-species in the future. During the follow up interviews, participants failed to recognize the purpose of the question, and regardless of the explanatory questions, participants' answers were limited with the definition. This finding can be attributed to the Turkish education system's tradional approaches in which students are perceived as the recipient of knowledge transferred by the teachers. Therefore, students are not exposed to the nature of knowledge, which requires the process of inquiry. Although there have been refom movements in science curriculum in 2004, content knowledge is still the main objective of teachers because of the high-stake testing in almost every stage of a student's educational life. Teachers, textbooks, and teaching methods, as well as the examination system, enforce this concept. Even though the renewed educational programs state the importance of the nature of science, participant preservice elementary science teachers' views were shaped by the traditional views of science.

Studies about students' and teachers' NOS understandings have shown that in non-European countries science is interpreted as a materialistic benefit rather than a way of knowing the natural world, and usually not involved in the learners' everyday thinking (Abd-El-Khalick & BouJaoude, 1997; Cobern, 1989). Similar with the previous studies Craven, Hand and Prain (2002) stated that the students'perception of science was either a body of knowledge (evidenced by a list of topics and concepts constructed by the students) or as a process (i.e. 'the scientific method') used to discover or 'prove' knowledge.

As stated by Akerson, Abd-El-Khalick, and Lederman (2000) experiences provided by limited instructional activities, even coupled with reflective elements during a science methods course, would not provide extensive changes in participants' NOS conception, which developed over their elementary and secondary education. For the present case, it can be suggested that the existing nature and history of science course in the undergraduate elementary science education program should provide compatible content with the science methods course and learning experiences which actively engage the learners in order to help develop contemporary understandings of the NOS.

Even though an explicit approach undertaken within science methods courses was successful in positively influencing teachers' NOS views, preservice science teachers need to have some level of NOS pedagogical content knowledge. Further research should be conducted with preservice science teachers for a combination of the teacher understanding NOS and how to teach it, as well as supporting the preservice teacher in planning and adapting the science curriculum to emphasize NOS. Researchers recommended building in a component of reflective practice of the NOS into the internship should be an important element of science teacher education (Sadler 2006; Akerson, Morrison & McDuffie, 2006; Luehmann 2007; Akerson, Buzzelli & Donnelly, 2010). Therefore, a way for the preservice teachers to share their NOS teaching practices and to receive feedback will encourage them to actually effectively integrate NOS into their teaching. It also can be recommended for inservice science teachers to be involved in action research practices focusing on NOS for their professional development.

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