Teaching nature of science to pre-service early childhood teachers through an explicit reflective approach

Emine ÇİL

Mugla Sıtkı Kocman University, Faculty of Education, Department of Science Education. Mugla-TURKEY

E-mail: ertennuran@hotmail.com

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Contents

Abstract

In this study, fifteen pre-service early childhood teachers' views of nature of science (NOS) were analysed. The student teachers took a course where NOS was taught via explicit reflective approach. The explicit reflective approach advocates that goal of improving students' NOS views should be planned for instead of being anticipated as a secondary product of science-based inquiry activities. The main purpose of the course is to develop the NOS understanding of the pre-service teachers and to encourage them to develop activities to teach NOS. Six explicit reflective NOS activities were implemented. The participants developed explicit reflective NOS activity which would be used in teaching one or more aspects of NOS to very young children. It was analysed in this paper that how the course changed the NOS viewpoints of the participants and what they thought about the course. The students teachers' views of the NOS were assessed using the Views of Nature of Science Elementary School Version-2 in conjunction with semi structured interviews. The data of regarding to participants' thought about the course was obtained their narrative. Before the course, it was determined that the pre-service teachers did not have the contemporary understanding about NOS. The course contributed them considerably to obtain informed views. After the course, they felt that they liked science more, their creative thinking skills developed, and they acquired the ability to look at the events from different perspectives.

Keywords: Nature of Science, Explicit Reflective Approach, Early Childhood Education, Pre-service Training

Introduction

One of the most important aims of science education is to help students comprehend the nature of science (NOS). However, it is clear from recent research that teaching practices in school that emphasize problem-solving, the development of cognitive abilities, and do not give importance the characteristics and development of scientific knowledge which continues to be used (Karakaş, 2009; Kattoula, Verma, & Martin-Hansen, 2009). The studies conducted also reveal the fact that high school (Dawkins & Dickerson, 2003; Liu, & Tsai, 2008; Moss, Abrams, & Robb, 2001; Rannikmae, Rannikmae, & Holbrook, 2006) and even PhD students (İrez, 2006) have naive/inadequate views about NOS and they have misconceptions in their minds about NOS. Some researchers such as Newton and

Newton, Lederman and O'Malley suggest that "it may be more productive to address the problem earlier and at its roots than to remedy older students' inadequate images about science" (Kang, Scharman, & Noh, 2005, p: 315). However, the studies of NOS were conducted mostly in primary, secondary and higher education levels and the young children were left out of the discussion because it is believed that they would not be able to conceptualize the NOS ideas (Akerson, Buck, Donnelly, Nargun-Joshi, & Weiland, 2001). The studies conducted recently reported that the children in the 3rd and 4th grades of primary education (Kawasaki, Herrenkohl, & Yeary, 2004), the first grade of primary education (Akerson & Volrich, 2006) and even the children at the age of pre-school (Akerson et al., 2001) would develop the conceptualization of NOS skills if it were taught with a suitable method. It is indisputable that the teachers play an important role while the students develop an appropriate NOS understanding (American Association for the Advancement of Science [AAAS], 1993; National Research Council [NRC], 1996). When Lederman (2006) analyzed the history of the studies conducted on NOS over 50 years ago, one of the generalizations he obtained was that unfortunately the view points of the in-service and/or pre-service teachers were not compatible with the contemporary concepts of scientific endeavor. If the teachers cannot achieve an appropriate NOS understanding, how can we expect them to help the children conceptualize their NOS ideas? (Akerson, Hanson, & Cullen, 2007).

This condition made popular the endeavors of in-service and pre-service teachers to develop their NOS concepts. Various approaches were undertaken to develop the NOS viewpoints of in-service and pre-service teachers. It was determined that explicit reflective approach was a successful method to develop the views of the teachers about NOS (Abd-El Khalick & Akerson, 2004; Akerson, Abd-El Khalick, & Lederman, 2000; Akerson & Hanuscin, 2007; Bell, Lederman, & Abd-El-Khalick, 2000; Küçük, 2008; Schwartz, Lederman, Khishfe, Lederman, Matthews, & Liu, 2002). When the NOS courses designed for the teachers were analyzed, what attracted me was that the target groups of the courses were usually in-service and/or pre-service primary and/or science teachers. Both the children of pre-school education and their teachers stayed away from the NOS researches. The variables such as how the courses changed the NOS understandings of the participants, how the participant teachers taught NOS in real class context after the course, how the NOS concepts of the students of these teachers changed were generally analyzed in the researches of designing NOS courses for the teachers. What the teachers who took the NOS course felt after the course was not paid attention very much. Because of all these reasons, the aim of this study is to teach the NOS to pre-service early childhood teachers with explicit reflective approach. The second purpose of the study is to evaluate the course based on the views of the student teachers and understand what they felt in the course.

1.1 Nature of Science

Although there is no universal definition of NOS agreed upon; NOS generally attributes to scientific epistemology, science as a way of knowing or the values and the beliefs existing in the nature of development of scientific knowledge (Lederman, 1992). It is undisputable that today K-12 students will be able to achieve some aspects of NOS. Five aspects of NOS emphasized by AAAS (1993), NRC (1996) and National Science Teachers Association (NSTA) (2000) were emphasized in this study. These elements consist of the following: scientific knowledge is tentative (subject to change), scientific knowledge is empirical (based on and/or derived from observations of the natural world), scientific investigation is theory driven (influenced by scientists' background and experiences), partly the product of human imagination and creativity (involves the invention of explanation) and the difference between observation and inference (scientific knowledge is partly a function of each).

1.2 Explicit Reflective NOS Instruction

Explicit reflective approach was first introduced by Abd-El Khalick, Bell and Lederman (1998) and then expanded and refined in a set of later studies (Akerson et al., 2000; Akerson et al., 2007; Akerson, Morrison, & McDuffie, 2006; Akerson & Volrich, 2006; Khishfe & Abd-El-Khalick, 2002; Khisfe, 2008; Küçük, 2006; Küçük, 2008). Within this framework, the label 'explicit' is curricular in nature while the label 'reflective' has instructional implications. The label explicit should not be equated didactic or direct instruction. The label explicit emphasize the learning about NOS should be planned intentionally as learning science concept or content, complex science theories, and development of scientific process skills. In the other words explicit approach is against of students would automatically develop better NOS conceptions as a by-product of engagement in science process skills instruction. It is possible that can be preferred different pedagogical approaches including those that are active, student-centered, collaborative, and/or inquiry-oriented in nature (Abd-El-Khalick & Akerson, 2009).

The 'reflective' component of the explicit–reflective approach to NOS designed to encourage the learners to look at their own science learning experiences from the epistemological framework (Abd-El-Khalick & Akerson, 2009). Abd-El Khalick and his colleague have fulfilled this component of approach it as structured and unstructured, written and oral exercises. Oral reflections are usually assigned during and after explicit instruction. With reflective writing assignments, students are given the opportunity to reflect in writing. In reflective writing assignments, a text containing aspects of the NOS in the education environment is usually prepared. Students are asked which of the NOS aspects are contained in the text (Akerson et al., 2000).

Method

This study is an interpretive research. Since the study focuses on the meanings attributed by pre-service early childhood teachers to the aspects of NOS emphasized before and after the three-month course, it is suitable to the nature of interpretive researches (Lawrence, 2010; Myers, 1998).

2.1 Context of the Study

The study was carried out in the Science, Technology and Environment Activities course, in which participation was volunteer-based and intended for the teachers of pre-service early childhood. The instructor of the course is author of this article. The training was spread over three months. The participants were taught each week two times in 50 minutes. The main purpose of this course is to the get the pre-service teachers to comprehend the importance of science education in pre-service early childhood stage, to acquire contemporary views about NOS, and to develop the skills to design activities for the understanding of aspects of NOS in early childhood stage.

2.2 Participants

Seventeen pre-service early childhood teachers registered to the course. The data for the study could be obtained from fifteen teachers. The age of the participants ranged between 20 and 38.

2.3 Intervention

The training span over three months is made up of three stages. The first two weeks of the training were designed as a workshop about the purpose of science education in early childhood stage, the roles and responsibilities of teachers in science education, the things to be paid attention during the design of science activities, and the importance of NOS education.

In the second stage, six activities of explicit reflective approach of NOS were implemented. These were; The Card Exchange, The Tangram, Sequencing Events, The Aging Teacher, Tricky Tracks, Hypothesis Boxes. A detailed description of these activities can be found elsewhere (Lederman & Abd-El Khalick, 1998; Doğan, Çakıroğlu, Bilican, & Çavuş, 2009; Küçük, 2006). The students worked in small groups in each activity. A whole class discussion followed each activity and in these discussions, emphasizing the target aspect of NOS explicitly was aimed at. All the in-class discussions gave the participants to talk actively about the ideas presented. For example, in the activity of Tricky Tracks, the difference between the observation and inference was discussed with the questions of “did you really see what happened in the scene of accident?” and “how did you decide what happened there?” The instructor encouraged the participants deliberately throughout the discussions to build connections between the activities they did and the real experiences of the scientists while reaching the scientific knowledge. One of them is like that: In Sequencing Events activity, the student teachers noticed the close similarity between their writing different stories from thirteen pictures and the scientists’ coming up with different theories about the reasons for the extinction of the dinosaurs resulting from the fossils.

In the last month of the course, the participants were asked to design explicit reflective activity to be used while teaching one or two aspects of NOS to very young children. While the participants were designing activities, they asked the trainer to do a group work. The participants wish was responded positively and they were given the opportunity to build their own work groups. So, everybody caught the chance to work with friends who they thought would be the most efficient. Since the participants formed groups of three and/or four, they presented four activities in total. Each week a group presented an activity which they developed themselves. The weaknesses and strengths of the activities were determined with whole class discussion and some suggestions were made to make it better. The NOS activities developed by the students are independent of science subjects like the activities taken from the literature. The activities developed by the students were introduced in Table 1.

Table 1: NOS activity of the subjects

Name of activity	NOS concepts	How the material is implemented?
Birthday cake	Theory driven	The children are divided in groups of two. The groups are given cake, cream, food coloring in three colors to color the cake, and different kind fruit such as kiwi, strawberry, and banana. Moreover, such tools such as cake topping apparatus, knife, fork and spatula. The children are asked to make a birthday cake. They can make their cakes in any shape such as round, square, and triangle and they can decorate it as they wish. The students are reminded to use each ingredient they were given while making their cakes. Although the students use the same ingredients, they can make a different cake. Although the scientists have the same data, it is discussed that they can reach different results.
Look at that paper	Tentative and interpretative	The aim of this activity is to teach the nature of science with origami. The teacher folds a square piece of paper and makes a dog, swan, crab, and a crane. For example, while the teacher is creating a dog with origami, s/he asks the children what the outcome will be after each folding step. The teacher asks the children to explain how they have decided the product to be. During this process, the teacher provides the children to be aware of the deductions they make from the data. The children's ideas about the product may change as the steps of folding progress. This condition is associated with the tentative element of science. Moreover, the teacher makes a dog and a swan from two identical square papers. It is observed that different products come out as a result of folding the same paper differently. This condition is associated with the fact that if scientific data is interpreted differently, the scientific results.
Funny cards	Empirical	Different cards with different colors (three red, three green, three blue) and geometric shapes (three triangles, three squares, three circles) are prepared. Different objects are drawn on these nine cards (three fruits, three numbers, and three animals). So, nine different cards whose colors, geometric shapes, and objects are different are obtained. A few sets of cards are prepared from these nine cards. So, a card pool is created. Eight of the cards are given to the students. The students are asked to classify these eight cards in itself according to any features they want (Some children can classify the cards according to their colors, some according to shapes, and some of them according to the objects on them). Every child examines the classification of his/her peer sitting next to him/her. S/he asks his/her peer to add one more card from the card pool in to his/her classification. The children

		explain why they take this card from the card pool. A relation between using some cues while choosing the cards and scientific studies' depending on data is established.
Listen to my tale	Theory driven and creative	Three pictures are prepared for each tale of Snow White and the Seven Dwarfs, The Tortoise and The Hare, Cinderella, and Tangled (Rapunzel). Twelve pictures were pasted randomly on a cartoon. The children are asked to put the pictures in correct order and create their own tales. The children tell their tales to their peers. The children are made to realize that by using the given pictures, they complete the missing parts with their own creativity and imagination and create tales. What draws attention is that by putting the same pictures in different order, everyone tells different tales. These experiences are associated with the theory driven and creative aspects of science.

Finally, in the last week of the lessons, the students were given a reflective writing assignment. The reading text was adapted from the preface of the book Shadows of the Mind: A Search for the Missing Science of Consciousness by Penrose (1994; pp: 1-4). A detailed description of this reflective writing task can be found elsewhere (Abd-El Khalick & Akerson, 2004; Akerson et al., 2000).

2.4 Instruments

The views of the participants about the NOS were obtained with Views of Nature of Science Elementary School Version-2, known as VNOS-D2 in literature and made up of open ended questions. The main reason for the choice of this questionnaire is that it has been frequently used in the studies conducted with the primary education teachers (Akerson et al., 2007; Akerson, Cullen, & Hanson, 2010). Following the questionnaire, semi structured interviews was made with the 33% of the participants (Lederman, 2007; Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). The interview helped to understand the views of the participants more in-depth and clearly. Moreover, the interviews served for the validity of the questionnaire.

Student teachers' ideas about the NOS instruction which they took throughout the course were obtained with narratives. On the last day of the course, the participants were asked to answer the nondirective question that is "what do you think about the activities you did in this course and the instruction carried out?" using the written expression.

2.5 Analysis

The views of the participants about the NOS were analyzed similarly to the systematic process followed by Khisfe (2008). First of all, the data of the questionnaire and the interviews were analyzed separately and compared. It was found that the questionnaire and interview data were matched with each other. This process revealed face validity. In the second stage, each view of the participants about the five target NOS aspects were categorized under no understanding, emerged understanding or informed understanding. The study conducted with the K-6 teachers by Akerson et al., (2007) guided this categorization. No understanding was designated to the answers which were given without understanding. For example, it was accepted as no understanding in tentative aspect of NOS if it was expressed that the scientific knowledge is absolute and it never changes. If a participant points both some understandings but also misconceptions, it is coded as emerging understanding. For example, a participant not only mentions that scientific knowledge can change in time but also states that science is a cluster of scientific knowledge whose accuracy is proved, the views of the participant in tentative aspect of NOS is emerged understanding. An informed view is coded when a participant has the full understanding of the concept and there is no compatibility with the answers (For instance, a pre-service teacher mentions that scientific ideas could change with the collection of new data or reinterpretation of existing data). Afterward, we generated pre- and post-instruction profiles of participants’ views of NOS. This stage consists of carrying out coding, verification and change for a few rounds. This process continued until we were satisfied with the reduction and organization of the data. In the third stage, the percentages of the students were evaluated for each target aspects of NOS in different categories (no understanding, emerging understanding and informed). The views of the students at the beginning and at the end of the study were compared. The transcriptions of VNOS-D2 questionnaire and the interviews were analyzed by the researcher and her colleague independently. Two analyses were compared and a great similarity was noticed. A consensus was reached for nearly with 10% different categorizations after negotiations.

Analysis of the narratives of participants’ relied on thematic content analysis, which is a descriptive presentation of qualitative data (Anderson, 2007; Aranson, 1994; Riessman, 2008). This type of analysis is used for making inferences about the characteristics or experiences of persons or social groups (Neuendorf, 2002; Smith, 1992). It allows themes to emerge from the data that are not imposed by the researcher (Fereday & Muir-Cochrane, 2006). The following steps describe how we identified themes and analyzed them. First of all, the narratives were read, and the all the explanations related to the research questions were highlighted with a marker. The pieces that are placed in different parts of the text which make up a meaningful whole were cut and combined and a pile was formed. These piles were the first themes/categories. These piles were labeled with a word or a sentence which reflected the point emphasized. As the data continued to be coded, both new themes were revealed and also the themes created were revised. After the data were coded and the first themes were formed, the holistic meaning of each theme was read, and in the meanwhile, themes were tagged again. This process was repeated for each narrative. The original narratives were reread without taking into consideration the categories formed a few days later. The meaning of the categories formed was reconsidered. The overall categories were taken as a whole and it was decided whether there were more categories or less categories than the categories in the narratives or not. In other words, whether the categories reflected all the data obtained or not were considered. This process was repeated until a satisfaction about the categories was provided. The data was then analyzed separately by independent coders. Afterwards, the analyses were compared. Misunderstandings were resolved via negotiations. A percentage distribution was done in order to find how many of the participants in the study internalized the emanating from the narratives. Moreover, direct quotes were cited from the narratives in order to understand the views of the participants better.

Findings

The findings related to the research questions were presented under two main titles in this section.

3.1 The Pre Service Early Childhood Teachers' NOS Views

How the views of the students about the target aspects of NOS changed before and after the instruction was presented in Table 2.

Table 2: Percentage change in participants' views of the target aspects of NOS

NOS aspects	No Understanding			Emerged Understanding			Informed		
	Pre-test	Post-test	Change	Pre-test	Post-test	Change	Pre-test	Post-test	Change
Tentative	20	0	-20	50	40	-10	30	60	+30
Empirical	10	0	-10	60	10	-50	30	90	+60
Theory driven	60	10	-50	20	30	+10	20	60	+40
Creative	20	0	-20	40	30	-10	40	70	+30
Interpretative	10	0	-10	60	50	-10	30	50	+20

3.1.1. Tentative aspect of NOS:

Findings from the Table 2 show that the views of half of the student teachers in the sampling of the study stated that science is dynamic. On the one hand, they defend that there is no possibility for present knowledge to be incorrect or change in the future.

> "Science always reveals knowledge whose accuracy is absolute everywhere. Because of this, it is out of question that scientific knowledge can change radically, but new knowledge can only be added to the former knowledge." (John)

When the course was completed, 60% of the participants adopted the informed views of tentative aspect of NOS. After a three-month instruction, there was no teacher candidate who has the view that scientific knowledge never changes. While 40 % of the participants explained in some questions that scientific knowledge can change, they could not continue their views in some questions.

> "Scientific knowledge can change in time. There are a lot of examples in history of science such as the shape of the Earth, formation of the universe, the movements of the planets ……... With the scientists' looking into the new data or present data without the new data through a different window, what we have learned as true can change today." (Natalie)

3.1.2. Empirical aspect of NOS:

According to Table 2, before the course, more than half of the participants (60%) have the views of empirical aspect NOS in emerged understanding category.

> "The most important feature of science that distinguishes it from other sciences is that science depends on experimental data. The scientists make explanations in the light of scientific data. ……. Another important feature of science is that it is objective. There are steps that the scientists follow. Anyone who follows the same steps achieves the same result at the end of the experiment." (John)

When the course was completed, 90% of the pre-service teachers reached the informed views of empirical aspect of NOS. They usually gave the following answers in the post test.

> "Scientific knowledge depends on the data obtained via systematic ways. Each scientist can follow a different systematic way. If the experimental data is not interpreted by the scientist, they cannot become meaningful."(Lauren)

3.1.3. Theory driven aspect of NOS:

Table 2 show that only 20% of the participants had the informed views of theory driven aspect of science before the course. Before starting the course, more than half of the pre-service early childhood teachers had not used any statements parallel with the contemporary viewpoint in the theory driven aspect of science. They thought that science is objective and they believed that when the scientists do not have enough data about the subject they work on, they come up with different results about the same subject.

> "It is quite normal to have many theories about why the dinosaurs became extinct because this phenomenon was experienced millions of years ago. We do not have enough data about this matter. If more and well-preserved fossils are found, a compromise about this matter can be obtained." (Sara)

When the course was completed, 60% of the participants had adopted the informed views of the theory driven aspect of NOS. Most of the students mentioned the Sequencing Events and The Aging Teacher activities shown to help the student teachers for the better understanding of theory driven aspect of science in course instruction.

> "As a human effort, science holds every single thing belonging to human beings in it. For example, the prejudices, prior-knowledge, and even the socio-cultural values of the society he lives in affect his studies. Although we had the same data, we came up with different ideas with the most of the

> activities we did in the course. For example, we wrote a story by putting the events in order in the pictures we were given in one of the activities…..” (Rachel)

3.1.4. Creative aspect of NOS:

40% of participants had the informed views of the NOS before they started the course. The same amount of the participants stated their views in the emerging understanding category of NOS. They had noticed that creativity and imagination was important in the acquisition of scientific knowledge. They think that creativity can be used for the determination of research topic of a scientific research, design of an experiment and implementation stages but the stages of interpretation of the data and getting to conclusion are separate from creativity.

> “Of course, scientific studies require creative thinking and imagination. The scientist answers such questions as what I can do on which topic, what kind of experiment I can do about this subject, what kind of result I can obtain with their creativity.” (Emily)

After the course, the ones who had informed views increased 30% and reached to 70%. What attracted the attention was that they expressed their views mostly by referring to Hypothesis Boxes and Tricky Tracks activities used in the course and to the whole discussions carried out in the class after the activities. Some participants mentioned the activities it is developed by student teacher within the context of the course.

> “We are shown a picture. What is asked in the picture? By using the information we gathered from the picture, we completed the remaining missing squares in our minds where creativity played an important role and we made interpretations. The scientists experience the similar processes in order to reach the results.” (Victoria).

3.1.5. Interpretative aspect of NOS:

According to Table 2, before starting the course, most of the participants (60%) had the emerged understanding views interpretive aspect of the NOS. In their written expressions and the verbal expressions in the interviews, they implied that the scientists made inferences. But, they couldn’t maintain their views throughout the questionnaire. It was observed in some of their statements that they perceived experimental data as if they were scientific results.

> "The scientists can understand what the dinosaurs looked like from the fossils of them. For example, when a fossil is uncovered, it is required that a comparison must be made between whether this fossil belongs to a living creature known till now or to a new species. ….. We can be sure about what the dinosaurs looked like because there are a lot of fossils preserved from them and if we join then together, what the dinosaurs looked like will be revealed." (Natalie)

After the instruction, 50% of the student teachers could explain the difference between the observation and inference as we have expected from the ones who have the contemporary viewpoints. They had written in their questionnaires that the scientists firstly reached the remains such as bones, footprint, and embryo to know that they really existed in the past. They continued their explanations by adding that by carrying out some researches on the data (such as making interpretations about the structure of chin if any remains belonging to tooth were found, doing chemical analysis on the fossils) the scientists had understood that the dinosaurs certainly lived in the past. In addition to all these, they determined that we cannot be sure about what the dinosaurs looked like. While defending their views, they implied that the scientists made inferences depending on the fossils.

3.2 The Pre Service Early Childhood Teachers' Views on Course Instruction

When the expressions of the participants were analyzed, their views about the instruction they took throughout the course were gathered in eight categories. Findings from Table 3 show that learning the NOS with explicit reflective approach made the 20% of student teachers like science. More than half of the participants had the views that before they participated in this course within the context of the study, they were not aware of some aspects of NOS and they had a big picture in their minds about the features of science after the course. 30% of the pre-service teachers stated clearly that the course they took within the context of this study changed the inadequate viewpoints about some aspects of NOS in their minds towards contemporary viewpoints. 40% of the participants think that the activities of explicit reflective approach of NOS carried out quite an efficient instruction. They stated clearly that each activity provided opportunities to experience an aspect of NOS focused on concretely. A great majority of student teachers (70%) wrote that the activities were great fun and these activities made the lesson enjoyable.

When Table 5 was analyzed, 20% of the pre-service teachers felt that learning NOS with explicit reflective approach developed their creative thinking skills. Nearly most of the participants thought that they made a habit of looking at the events/situations they encountered from different perspectives after the course. 80% of the participants determined that learning nature of science with explicit reflective approach is a guide for them to teach science to young children in their teaching profession.

Table 3: Participants' views about NOS instruction

Categories	%	Participant statement
Love science	20	"I was always shy in science courses. I thought that science was a difficult course to learn. I think that it is due to the science education I had in the schools. The activities which we discussed the features of science even made somebody like me, who has prejudices against science, like science." (Victoria)
Completing the missing parts about nature of science.	60	"Before taking this course, I realized that I was not aware of some features of science. For example, the prior knowledge of the scientists, the points of views they have, and socio-culture values of the society they live in and etc. can affect their interpretation of the data. Just like the different interpretations of two people looking at the same pictures. I have never thought over this feature of science before." (Jessica)
Correcting the mistakes about nature of science	30	"I, who is going to be a teacher next year, realized that I had some wrong ideas about what science is. Before this term, I thought that because scientific knowledge was proved to be absolute, it would never change. After the term, I don't think so. In many activities we did, we reached the conclusion that the knowledge which we accept to be true today will change and/or develop. We gave examples about a lot of topic such as the formation of the Earth and planets to show that our knowledge is changing and developing." (Maria)
Providing effective teaching	40	"I think that the activities of nature of science are quite effective because we had the opportunity to experience each feature of science perceptibly with the activities. For example, we made inferences by using the data in the activity like the scientists. If I had bought a book about nature of science and read it would not have been as effective as this." (Jennifer)
Enjoying the	70	"Most of the activities were attention grabbing and

activities		enjoyable. I have never thought that science would be so enjoyable." (Alexandra)
Supporting creativity	20	"We generated results with imagination and creativity with most of the activities. …..During the term, besides the activities our teacher brought to the class, we also designed activities for pre-school children to have them comprehend the features of science and scientific knowledge. Our teacher wanted the activities we developed to be authentic. Because of this, we had to know the present activities in order to design the activities but it was not enough. There had to be pieces in the activity which belonged to us. It was challenging for me at the beginning. I thought for day, did research, and discussed it with my friends, as the scientists did. In the end, a product belonging to me was generated. What's more, I can think more creatively." (John)
Acquisition of habit of looking at from different perspectives	90	"There was not a single way to get to conclusion in the activities we did. Each student in the class interpreted the case by looking at it from different perspectives. Interpretations which I had never thought before were made in the activities of putting the events in order and foot prints. From now on, I'm trying to look at every situation I come across from different perspectives." (Gabrielle)
Professional benefit	80	"The activities we did about the nature of science (tangram, putting the events in order, old teacher and so on) became the guides for us about what we should do and how we should do in order to have the young students acquire the correct view point. Moreover, I'm thinking of using these activities, and the activities developed by me and my peers in my professional teaching life." (Amanda)

Discussion

Before the instruction most of the pre-service early childhood teachers did not have the contemporary viewpoints about the tentative, empirical, theory driven, creative and interpretive aspects of NOS and they had many misconceptions in their minds. These results recapitulate the results of many studies conducted with pre-service and in-service teachers (Akerson et al., 2000; Akerson et al., 2007; Buaraphan & Sung-Ong, 2009; Chin, 2005; Çelik & Bayrakçeken, 2006; Küçük, 2008). After a three-month course, 50% and more of the participants, where this ration went up to

70% and 90% with some aspects, obtained informed views. These findings reveal that the course carried the NOS understandings of all of the participants towards contemporary viewpoints. It is not realistic to expect for any course or program to provide full understanding for the target aspects of nature of science. In this regard, the picture after the course was quite successful. These results support the studies which reveal that explicit reflective approach is effective in teaching NOS (Akerson et al., 2000; Akerson et al., 2007; Akerson et al., 2006; Bell et al., 2000; Khishfe & Abd-El-Khalick, 2002; Küçük, 2008; Schwartz et al., 2002; Veal, 2004).

I can explain the change in the views of the student teachers about NOS with two reasons. One of the reasons is the explicit reflective approach activities which were implemented during the course instruction. The participants had experienced what the scientists experienced in real scientific study in the activities. Of course, these features of the activities are important but in order to make someone realize the NOS, they need implementations more than having experiences about a scientific study (Abd-El-Khalick & Lederman, 2000; Khishfe & Abd-El-Khalick, 2002; Lederman, 2006). Because of this, I would like to draw attention to how valuable the whole class discussions which follow the activities were. All the whole discussions were revolved around two main points. First of all, the questions which the activity focused on and helped to realize the aspects of NOS were discussed. For example, in Sequencing Events activity, after the small group completed its work, with the question of "how can you explain writing tales although you have the same picture?" it was aimed that the participants would notice that the same data would be interpreted differently. The theory driven and interpretive aspects of nature of science were explicitly emphasized with the answers given to this question. The expressions of a student in the lesson such as "Nobody had asked me such questions as what is science? What is inference? I question them for the first time and I realize my own opinions." point that it is so important to emphasize the nature of science explicitly. The second point which was emphasized in whole class discussions was that the students built up close relations between the activities they developed and the scientific endeavor. In other words, they made reflections about the aspects of nature of science focused on. For example, in the Sequencing Events activity, the participants were able to build bridges between their own life and presentation of different theories about global warming and the formation of the universe.

In my opinion, the second reason for the positive change in the views of the participants about the target aspects of NOS is that the participants themselves designed an explicit reflective approach activity of NOS. What I observed in my study was that when I first asked the student teachers to develop activities, they thought that it was a very difficult task and they were worried that they could not achieve the task. As they analyzed the explicit reflective approach activities of NOS in literature, and talk with their friends about what they could do, they began to shape their own activities. After the first steps of the designing activities, the reduction in the worries of the participants drew my attention. Each week, a group presented their activity, the strengths of the activity were revealed with the whole class discussion, and some suggestions were made to make it better. All these implementations might have provided support to make the understanding of NOS obtained by the participants in the first stage of the course easy to understand and elaborate (Küçük, 2008). Maybe some viewpoints which could not be achieved in the first stage of the course were discovered during the activity development process. Depending on all these explanations, I might suggest that the courses where the explicit reflective approach of NOS is taught to the early childhood teachers and the teachers developed their own NOS activities should be designed and implemented. The NOS activities chosen by the instructor and the activities developed by the participants are independent of science content in this study. In the courses which will be designed after this, the instruction may be started with the activities separate from science content, and it can continue with the NOS activities depending on research within the science context. While the student teachers learn the NOS, they can also develop their science concepts and knowledge by this way.

The participants who joined the course of Science, Technology, and Environment Activities reported positive views about the instruction they took throughout the course. The results I obtained support the assertion by Veal (2004) that pre-service and in-service teachers enjoyed the courses where the NOS were taught. Moreover, Tao (2003) in his study conducted with junior secondary school students used science stories to develop the understanding on NOS. Tao reported in the interviews made by the students that the students liked the stories. As it is with my study, after a course where the NOS was taught with explicit reflective approach for three months, it is not surprising for the participants to make such sentences as “I corrected my mistakes, I learned what I did not know about the NOS, I am thinking of using these activities in the real class environment.” It may not be surprising but it is pleasing that the participants felt these after the course. To me, the instruction of NOS causing the pre-service teachers to like science, feeding their creative thinking skills, having them acquire the habit of looking at events from different perspectives are very valuable outcomes to be emphasized. Such feelings of the student teachers may result from internalizing what science is and how it works. Perhaps, how instruction of NOS changed the views of the people about the NOS and also the question of how and what it affects may be sought answer with the studies to be conducted in the future.

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