The Effect of Explicit-Reflective and Historical Approach on Preservice Elementary Teachers' Views of Nature of Science

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Abstract

This study aims to explore the influence of nature of science (NOS) activities based on explicit-reflective and historical approach on preservice elementary teachers' views of NOS aspects. Mixed-method approach including both qualitative and quantitative methods was used. The sample consisted of 83 preservice elementary teachers of a public university. Activities in experimental group were prepared as per explicit-reflective approach, whereas per historical approach in the other group. Views of NOS questionnaire was applied both as a pretest and posttest to explore students' views about NOS aspects. During a 3-week application, worksheets were used and we benefited from observation checklists to control potential threats to internal validity. While content analysis method was used in qualitative analysis; frequency, percentage, Wilcoxon sign and Mann-Whitney tests were facilitated in quantitative part. Results indicated that students who experienced explicit-reflective instruction made statistically significant gains in their views of NOS aspects and accordingly some implications were presented.

Keywords: Nature of science, explicit-reflective approach, historical approach, preservice teachers

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Introduction

Contemporary science education reform endeavors have highlighted the development of precise understandings of the nature of science (NOS) (Bell, Matkins & Gansneder, 2011). Individuals in the science community should have an adequate understanding of NOS to be qualified as scientifically literate (McComas, 1998). Scientific literacy is defined as having a knowledge of science; that is, knowledge of NOS (McComas, Clough, & Almazro, 1998). No consensus exists among science historians, philosophers and educators on the definition of NOS. Typically, NOS is used to express the epistemology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge (Lederman, 1992). McComas et.al. (1998) offered one of the most widely used definitions of NOS:

> NOS is an efficient and a complex area encompassing more than one discipline. NOS is a hybrid arena which blends aspects of various social studies of science including history, sociology and philosophy of science combined with research from the cognitive sciences such as psychology into a rich description of what science is, how it works, how scientists operate as a social group and how society itself both directs and reacts to scientific endeavors. (p. 84)

Researchers and educators generally refer to the characteristics of scientific knowledge when they define NOS. Although researchers and educators have not come to a consensus as to the specific definition of NOS, they have achieved some agreement on the characteristics of NOS among the works to improve science education (Abd-El-Khalick & Lederman, 2000; Lederman, 1992; Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). The main aspects of NOS are as follows: scientific knowledge is empirically based (based on and/or derived from observations of the natural world), tentative (subject to change), subjective (affected by scientists' past experiences and biases), partly the product of human imagination and creativity (involves the invention of explanation), socially and culturally embedded, distinct between observations and inferences, and a function of the relationships between scientific theories and laws (Abd-El-Khalick, Bell, & Lederman, 1998).

Both textbooks and the media discuss NOS in detail. However, studies have revealed that information written in books and appearing in media includes many misconceptions related to understanding science (Abd-El-Khalick, Waters, & Le, 2008). Numerous studies have shown that teachers, preservice teachers, students, and instructors do not have adequate views of NOS, and the views they do have are not consistent with contemporary conceptions of the scientific endeavors (Abd El-Khalick et al., 2008; Dogan & Abd-El-Khalick, 2008).

The controversial issues related to teaching science and NOS in education stem from how to implement various programs. Teaching the features of NOS has long been a common goal for science educators (Abd-El-Khalick et al., 1998; Lederman, 1992). Since science courses that integrate and efficiently organize NOS have a significant potential to ensure that students develop the skills to cope with problems they might encounter in their daily lives (National Research Council [NRC], 2000). Studies investigating the best approach to teach NOS focus on three categories of approaches: (a) implicit, (b) historical, and (c) explicit-reflective (Abd-El-Khalick & Lederman, 2000; Khishfe & Abd-El- Khalick, 2002).

The implicit approach assumes that individuals can learn NOS by "doing science" and participating in "scientific activity" (Abd-El-Khalick & Lederman, 2000). However, researchers have shown that the implicit approach is not effective in helping students develop informed NOS views (Bell et al., 2011; Kim & Irving, 2010; Lederman, 1992; Trent, 1965). Trent (1965) reported that the inquiry-oriented Physical Science Study Curriculum (PSSC) was not more effective than a traditional textbook-centered curriculum in enhancing students' NOS views. In Moss, Abrams and Robb (2001)'s study with students from 11 to 12 years old, they explored students' views of NOS in the science course based on the implicit approach for one academic year. The results of the study have revealed that the implicit approach was ineffective in improving students' concepts of NOS. On the contrary,

Meichtry (1992) investigated the effect of the implicit approach on middle school students' views on the progressive and testable NOS and concluded that it was effective.

The historical approach is an approach that suggests using case studies in teaching scientific information on how to proceed in the historical process. It recommends that incorporating history of science in science teaching can serve to improve students' NOS views (Khishfe & Abd-El-Khalick, 2002). Thus allowing the discovery of similarities between their own ideas and the thoughts of past scientists will enable students to see the value of their own ideas without being assessed individually. Successful implementation of the historical approach requires suitable curriculum materials, and teachers' use of appropriate models with students as well as appropriate subjects and educational environments can affect the success of the historical approach. Stinner, McMillan, Metz, Jilek and Klassen (2003) identified six different ways of utilizing the historical approach in science education: drama, dialogues (conflicts between persons), confrontations (conflicts between two or more theories), thematic narratives, vignettes (short descriptions of historical events), and case studies. Tolvanen, Jansson, Vesterinen and Aksela (2014) also mentioned that historical experiments can be used in the historical approach, either by discussing the experiments or actually conducting them. Many studies (Besli, 2008; Dass, 2005; Dogan & Özcan, 2010; Irwin, 2000; Solomon, Duveen, Scot, & Mccarthy, 1992) have examined the historical approach in general or the overall impact of the models used in the teaching of NOS. For example, Chamnanwong and Yuenyong (2014) reviewed literature related to how to teach NOS through the history of biology. In another study, Tolvanen et al. (2014) concentrated on the historical approach in secondary school chemistry education, especially in terms of facilitating history as a context to teach about NOS. Lin and Chen (2002) in their work with preservice teachers have observed that the historical approach has a significant effect on the development of concepts about NOS. However, in their study with university students and teachers, Abd-El-Khalick and Lederman (2000) concluded that the impact of the historical approach on the development of participants' concepts about NOS was substantially low.

The explicit-reflective approach argues that NOS should be taught directly and must be planned effectively instead of waiting to be learned as a byproduct (Abd-El-Khalick & Lederman, 2000). In addition; discussions, reflective notes and special activities are particularly used in this approach (Schwartz, Lederman, & Crawford, 2004). Considering the studies related to the teaching of NOS, the explicit-reflective approach appears to be effective in improving the understanding of NOS (Abd-El-Khalick & Akerson, 2004; Abd-El-Khalick & Lederman, 2000; Akerson, Donnelly, Riggs, & Eastwood, 2012; Bell et al., 2011; Schwartz et al., 2004). In most assessments about the effectiveness of the explicit-reflective approach, researchers have benefited from single practical case studies not including the comparison group. Unfortunately, very few studies compare the explicit-reflective approach with the implicit and historical approaches (Ayvacı, 2007; Khishfe & Abd-El-Khalick, 2002). Moreover, researchers have worked primarily with high school students and high school science and mathematics teachers (Khishfe & Abd-El-Khalick, 2002; Leblebicioğlu, Metin, & Yardımcı, 2012). According to the relevant literature, students and teachers have similar misconceptions about NOS (Khishfe, 2008; Morrison, Raab, & Ingram, 2009). In this respect, teachers should be trained to understand NOS. If teachers have misconceptions about NOS, their reflection of these misconceptions on their students becomes natural. Therefore, preservice elementary teachers, as the elementary teachers of the near future, need to understand NOS better.

Although several studies have examined the effectiveness of the explicit-reflective approach to teaching NOS, the number of studies that directly or indirectly compare the explicit-reflective approach with implicit and historical approaches is limited and inadequate. Hence, conducting such mixed method studies or comparative experimental research is expected to contribute to the literature. Therefore, this study compares the explicit-reflective approach and historical approach to determine which is more effective in teaching NOS. By considering the lack of various studies in the relevant field, this study aims to explore the influence of NOS activities based on the explicit-reflective and historical approaches on preservice elementary teachers' views of NOS. Participants' views related to six NOS aspects (empirical based, tentative, partly the product of human imagination and creativity,

subjectivity, distinction between observations and inferences, relationships between scientific theories and laws) are specifically examined. In this context, the research question and sub-problems are expressed as: What is the influence of NOS activities prepared based on the explicit-reflective and historical approaches on preservice elementary teachers' views of NOS aspects?

Sub Problems

1. How are preservice elementary teachers' views related to six aspects of NOS before implementation?
2. How are preservice elementary teachers' views related to six aspects of NOS after implementation?
3. Are there any significant differences between pre and posttest distributions for each NOS aspect of the experimental group (EG) implemented with NOS activities based on explicit-reflective approach?
4. Are there any significant differences between pre and posttest distributions for each NOS aspect of the comparison group (CG) implemented with NOS activities based on historical approach?
5. Are there any significant differences between experimental and comparison groups' pretest distributions for each of the aspect of NOS?
6. Are there any significant differences between experimental and comparison groups' posttest distributions for each of the aspect of NOS?

Method

Research Design

In this study, a mixed method design including qualitative and quantitative methods was used to provide a more complete understanding of the issue and to examine the effectiveness of the explicit-reflective approach and historical approach. In particular, researchers were pursuing the concurrent embedded strategy in which qualitative and quantitative data were collected simultaneously. Concurrent embedded strategy is characterized by a first method (in this case qualitative), and a second method (in this case quantitative) (Creswell, 2009). In this study, qualitative data were used to examine in depth the views of preservice teachers before and after treatment. The quantitative data were used for the purpose of making comparisons between groups within themselves and groups.

Participants

In the selection of the participants, convenience sampling method was used to gain speed and practicality to the research. The study group was composed of 83 preservice elementary teachers (58 females, 25 males) of a public university in Zonguldak. All of them were in their second year and at the same age. Classes were randomly assigned to the experimental and comparison groups. The EG was composed of 32 females and 10 males, and a total of 42 preservice teachers. The CG consisted of 26 females and 15 males, and a total of 41 preservice teachers. Up to this time, preservice elementary teachers took general history lessons under the name of "history of civilization" and "culture and history of the country". They did not receive any lesson specifically for NOS. No specific differences between preservice teachers were noticed in terms of characteristics. Apart from the studied or controlled variables, it was assumed that participants in this study had similar subject characteristics.

Instruments

The Views of Nature of Science Questionnaire Form-B (VNOS-B) (Lederman et al., 2002) was applied as a pre and posttest to reveal preservice teachers' views about NOS. This questionnaire was administered to students in several studies (Akerson, Abd-El-Khalick, & Lederman, 2000; Bell et al., 2011). According to other surveys and analyzed interview data in these studies, the validity of the questionnaire was provided by systematically comparing NOS profiles of participants. In our study, opinion of an expert in the related field was taken for the content validity evidence. In addition, VNOS-B was administered to a similar group in a pilot study. VNOS-B used in the main study was taken from Bell and Lederman (2003) and contained six open-ended questions. The first question of this questionnaire was intended to uncover "tentative" aspect of NOS, the second one was for "observation and inference", whereas the third question was for distinction between "theory and law". The fourth question of VNOS-B was designed to investigate both "subjectivity" and "empirically based" aspects, while last two questions were facilitated to expose "imaginative and creative" nature of scientific knowledge.

Another instrument used in this study was students' worksheets. They were collected to support the reflection of the implementation process as data triangulation and it was intended to contribute to the validity of the research in this way. These worksheets were composed of two parts in which students need to fill them during and after the activity. Preservice teachers in both groups individually completed the worksheets prepared by researchers. Worksheets included open-ended questions about the activity or parts where students were asked to draw their own models related to the activities. Worksheets continued as long as activity applied in both groups. All of these worksheets were used as an important data source for both the evaluation of activities and how they established a relationship between NOS and the implemented activities. Direct quotations from these worksheets were given to contribute the outcomes of the study.

Observation checklists were used to control possible threats to internal validity in this study. Therefore, items forming observation checklists were related to classroom environment, researchers, teachers and activities. These observation checklists prepared by one of the researchers and consisted of 16 items. Instructor of the course followed the activities conducted in both classes and accordingly filled out observation checklists during the event. One of the researchers completed the checklists after the class since she actively carried out the activity during the intervention. A total of 12 (half by instructor and half by one of the researchers) observation checklists was filled out at the end of the study. Correlation coefficients were calculated for the harmony of two observers' assessments about 16 items in observation checklists. These inter-rater correlation values changing between .73 and .79 were found statistically significant at .01 levels.

Intervention

This research was carried out in an environmental education course located in primary education program. The treatment period of this study including the implementation of pre and posttests covered a total of 5 week process. Activities that were applied to the experimental and comparison groups were performed by one of the researchers. This researcher administered VNOS-B as a pretest to both groups in the same day. After this implementation, NOS activities prepared with explicit-reflective approach were applied to preservice teachers for three weeks. Activities used in the EG were adapted from Küçük (2006) to allow examination of six aspects of NOS (empirically based, tentative, imagination and creativity, subjectivity, difference between observation and inference, relationship between scientific theories and laws). These activities were Tricky Marks, Magic Pipe and Water Generator. The implementation of each took about 50 minutes. The contents of these activities are given in Appendix. In each activity, related worksheets were given to preservice teachers at first and the activity was begun after a brief introduction was made.

In the first activity, preservice teachers have worked individually and also completed worksheets on an individual basis. In the other two activities teachers have formed groups of 4-5

people. They did the activities as a group, however they individually filled out worksheets. At the beginning, some figures were reflected on the board via projector and accordingly preservice teachers were asked to write their thoughts related to "what they see" and "so what could be" to their worksheets. After completing this process, preservice teachers were expected to share what they wrote in the classroom. Finally, a discussion environment was created in class with various questions posed.

In the second activity, prepared pipe system was introduced to the preservice teachers by pulling ropes to the right and left to indicate what was happening. They were told to monitor the event carefully and write their observations on worksheets. Preservice teachers were expected to establish hypotheses about what might happen in the model. They were said to build their pipe models with the given toilet paper rolls and paper clips, after all group members agreed on the models established depending on these hypotheses. Ready groups that recorded their models on their worksheets were tried to observe whether their models act as the introduced one.

In the last activity, an exciting explanation regarding the vehicle to be used was made to stimulate preservice teachers' curiosity. Then each of the students was asked to fill out the worksheets after carefully observing the pre-prepared "water generator machine" shown to them. Each group was expected to construct a working model thinking about how the mechanism works. Preservice teachers were provided to discuss why and which of the model established by groups was better. In this way, particular attention was paid to clearly give the elements of NOS during the application of activities in the EG.

Contrary to approach used in the EG, NOS activities based on historical approach was applied in the CG. Passages describing sections from history of science were given to the preservice teachers for 3 weeks. These passages have been adapted from the study of Yıldırım (2005). The adapted texts were related to Archimedes, Marie Curie and Albert Einstein. The content of these activities implemented in the CG are given in Appendix. During the treatment period, worksheets including passages were given at first to preservice teachers in each of the activities. Implementation of activities has begun after shortly introducing them. Students were asked to read the given passages twice. In the first reading, they were expected to just read the passage and understand it. In the second purposive reading, preservice teachers were supposed to find examples about how science in passage changes, how it affects or being affected by technology and the community. When all preservice teachers finished their second readings, researcher took the role and has turned the event into classroom discussions through the examples they have found.

Instructor of the course monitored the activities conducted in both classes to control some of the possible threats to internal validity of the research and accordingly completed observation checklists during the activities. At the end of the application of activities, VNOS-B was administered to both groups as a posttest in the same day.

Data Analysis

Preservice teachers' pre and post profiles for six aspects of NOS were tried to be established to clearly put forward their views about NOS depending on the data derived from the responses to the survey questions. The data obtained from VNOS-B were analyzed using content analysis technique. Preservice teachers' views related to NOS aspects stated in questionnaires were encoded using the same leveling (informed, adequate, and inadequate) employed by Akerson et al. (2012). These were consecutively representing a highly developed sense of understanding, improved views, and misconceptions about NOS. These levels or groupings were also recoded as 3, 2, and 1. Analysis of the data was carried out by using this coding. Some of the examples how the preservice teachers' views were grouped are shown in Table 1.

Table 1. Sample Views for "Inadequate", "Adequate", "Informed" Groupings

Coding	Related Views
Inadequate	— If supported, theory would be law. — Scientific knowledge does not change. — Evidences must be directly observed. — Scientists do not use their creativity and imagination. — Science is objective.
Adequate	— Scientific knowledge only changes when new information is added. — Theories and laws are different, but laws are more accurate scientific knowledge. — Scientists may see the data different (cannot explain its reason).
Informed	— Scientists use their creativity and imagination. — Scientists may make inferences from their observations. — Theories and laws are different scientific knowledge and both can change. — Scientific knowledge may change in all circumstances. — Scientists may interpret data differently due to their divergent socio-cultural environments and experiences.

Descriptive statistical methods of frequency and percentage were used in analyzing preservice teachers' views related to fundamental aspects of NOS. Inferential statistics methods of Wilcoxon sign and Mann-Whitney tests were facilitated to examine students' views in both pretest and posttest related to basic aspects of NOS.

Evaluation of the VNOS-B used in this study was carried out by two raters. At the beginning of coding, raters encoded questionnaire together to determine the points to be considered in coding procedure. Then they encoded surveys individually. The percentage of comparative agreement between the two raters was calculated by using the formula suggested by Miles and Huberman (1994). The corresponding calculated value of 91% implies a high harmony between encoders.

Results

Descriptive Statistics

Table 2 shows the distributions of preservice teachers' views related to six aspects of NOS maintained by implementation of VNOS-B both as a pretest and posttest. Students are categorized according to their groups and three coding in this table. To make it a little more straightforward, the number of preservice teachers in each group, and coding without adding their percentages are given in Table 2.

Table 2. Distributions of Views Related to NOS Aspects According to Groups

NOS Aspect	Pretest	EG Posttest			CG Posttest		
		Informed	Adequate	Inadequate	Informed	Adequate	Inadequate
Empirically Based	Informed	2	0	2	0	0	3
	Adequate	2	1	1	0	1	2
	Inadequate	5	9	20	2	2	31
Tentative	Informed	6	1	0	3	5	0
	Adequate	18	15	0	7	23	2
	Inadequate	2	0	0	0	1	0
Imaginative-Creative	Informed	6	0	0	1	4	2
	Adequate	10	17	1	1	21	4
	Inadequate	1	5	2	2	6	0
Subjectivity	Informed	1	2	0	0	0	0
	Adequate	16	8	2	1	8	7
	Inadequate	2	7	4	1	13	11
Observation-Inference	Informed	2	0	0	0	1	0
	Adequate	5	1	1	0	0	1
	Inadequate	9	12	12	2	5	32
Theory and Law	Informed	1	0	0	0	1	0
	Adequate	4	12	5	0	14	7
	Inadequate	3	12	5	1	11	7

As seen from Table 2, the most problematic NOS aspects for both groups are "empirically based" and "observation-inference". It is also understood that the least problematic aspects of NOS in which preservice teachers have less "inadequate" views and more "adequate" views are "tentative" and "imaginative-creative". Considering increases (from "inadequate" to "adequate" or "informed", and from "adequate" to "informed") in preservice teachers' NOS views related to students' pre and posttest data, it is seen that there are different distributions in terms of the CG and EG. The highest increase in the EG occurred in "observation-inference" aspect of NOS with 26 (5+9+12) preservice teachers and 62% (26/42) ratio, while one of the least increase formed in "imaginative and creative" aspect with 16 (10+1+5) students and 38% (16/42) ratio. In the CG, the highest increase calculated in "subjectivity" aspect of NOS with the rate of 37% (15/41), whereas the least increase took place in "empirically based" aspect with the ratio of 10% (4/41). In addition, it is also recognized that the growth rates for the EG are more than those values for the CG in whole aspects of NOS.

Empirically Based Nature of Scientific Knowledge

It is important to examine all aspects of NOS in detailed. In this context, 81% (34/42) of the preservice teachers in the EG and 86% (35/41) of the students in the CG notified "inadequate" views related to "empirically based" aspect of NOS in the pretest. But in the posttest, 55% (23/42) of the participants in the EG and 88% (36/41) of the individuals in the CG informed "inadequate" views. That is, the number of students stating "inadequate" views is reasonably reduced finally. In addition, %22 (9/42) of the preservice teachers in the EG have said that data are collected via research, experiment, and observations during the production of scientific knowledge. Expressions of seventh and thirtieth preservice teachers in experimental (E) class related to this aspect:

> Science is based on experiments and observations, while there are no experiments and observations in art. (E–7)
>
> Experiments and observations are made using scientific methods in science so that data is collected, there is no such thing in art. (E–30)

When preservice teachers' worksheets related to "Water Generator" activity analyzed, it is also seen that students talked "empirically based" aspect of NOS. A contributing example:

> I tried to build my model according to data I obtained from my observations during this activity. (E–8)

Preservice teachers in the CG have mentioned in their worksheets that scientists had reached scientific knowledge based on empirical data as indicated in the passages that describe their lives. A crucial outcome for this aspect of NOS is that five preservice teachers in the EG could pass from "inadequate" to "informed" category in the posttest, whereas only two of them in the CG increased to "informed" views finally.

Tentative Nature of Scientific Knowledge

At the beginning of the research, 5% of the preservice teachers in the EG and 2% of the participants in the CG stated "inadequate" views related to "tentative" aspect of NOS. In the pretest, the rate of students having views in "adequate" category was 79% in the EG and 78% in the CG. However, 62% of the preservice teachers in the EG and only 25% of the students in the CG took place in "informed" category at the end of the study. In the pretest, 79% students in the EG accepted the idea of theories may change unlike laws. Some of the examples related to this issue can be stated as:

> Theories may change. Since none of the theories are laws. (E–3)
>
> Theories can change because they are not absolute. Or progresses, finalizes to become law or turns invalid and cancelled. (E–12)

When students' worksheets analyzed, it is seen that preservice teachers have mentioned this aspect of NOS in almost every activity. An expression of a preservice teacher in the EG maintained from "Tricky Marks" activity worksheets is as follows:

> I liken to footprints remained in the snow when I first saw the figures. But I liken to migrating birds when I saw the second shape. At the end of the activity, I understood that the thoughts of scientists can also be changed later in the same way when they obtained other evidences, so that scientific information is also changed. (E–7)

An excerpt from fifth student's worksheet about the activity of "Marie Curie: Woman died for science" in comparison (C) group:

> The famous physicist Becquerel was thinking that there is another element in uranium mine ore except uranium. Couple Curie examined this claim of Becquerel and reached the conclusion that it is not a known element instead it is a new element. Therefore as seen from this sentence, scientific knowledge is constantly changing and developing. (C–5)

Results of the study indicate that the rate of preservice teachers in "informed" category increased 45% in the EG and only enlarged 5% in the CG at the end of the work. Furthermore, the number of preservice teachers passing from "inadequate" to "informed" category is larger in the EG.

Imaginative and Creative Nature of Scientific Knowledge

In the pretest, 67% of the preservice teachers in the EG and 63% of the individuals in the CG reported "adequate" views related to "imaginative and creative" aspect of NOS. The rate of the students composed of 53% in the EG, whereas 76% in the CG at the end of the study. An important point should be noted in here is that only one preservice teacher in the EG could pass from "inadequate" to "informed" category at the end, whereas 10 of them increased their "adequate" views to "informed" in the posttest. Another point should be highlighted is that despite a reduction in the

number of students in the CG having "informed" views, one more students in the CG passed from "inadequate" to "informed" category at the end. An example from the CG coded as "informed" in the posttest:

> Used at each stage. The scientist conducts experiments and observations by using his imagination and creativity. (C–11)

Preservice teachers in both groups talked about this aspect of NOS in their worksheets:

> Each group has built different models in "Magic Pipe" activity. In fact, we all think differently even though we all look at the same data. At this point, our creativity of "Archimedes: I found it, I found!" activated. (E–28)

> In the "Archimedes: I found it, I found!" activity, it comes to mind of Archimedes whenever he stepped his foot in the tub. Why did not anyone else think of the same? Archimedes used a kind of imagination and creativity in here. (C–22)

Subjectivity Aspect of NOS

Preservice teachers views related to "subjectivity" aspect of NOS differ in the pretest. Students in the EG with 62% mostly declared "adequate" views in the pretest, whereas preservice teachers in the CG with 61% mostly stated "inadequate" views. In the posttest, 45% of students in the EG appeared in "informed" category, but only 4% of preservice teachers in the CG were in this category. The positive point about this aspect is that the number of students' having "informed" views in both groups increased and those holding "inadequate" views decreased in the posttest. In this context, most of the increase occurred for 16 students in the EG by changing their "adequate" views to "informed" views in the posttest. The largest increase in the CG is formed with 13 preservice teachers by improving their "inadequate" views to "adequate" views. A preservice teacher's "informed" view related to this aspect is:

> Astronomers are taking into account the results of the same experiments and data, but what each of them understand and infer from that experiment is different. Since each lives in different environments and has different experiences. This is due to the fact that science is subjective. (C–30)

Preservice teachers regard the aspect of "subjectivity" as one of the reasons for making different interpretations even though they are looking at the same data of the worksheets used in "Tricky Marks" activity. A related example:

> In fact, we all looked the figure projected on the board. But what we all see, interpret was different. Because we are all different. We all have different experiences and history. (E–16)

Distinction between Observation and Inference

At the beginning of the study, 79% of the preservice teachers in the EG and 96% of the individuals in the CG had "inadequate" views related to "observation-inference" aspect of NOS. In the pretest, the ratio of preservice teachers having views in "informed" category was 5% in the EG and 2% in the CG. Preservice teachers in both groups stated that they can observe atom directly with microscope in the pretest. An example:

> Scientists have determined the structure of the atom by making many experiments with special microscopes. (E–18)

At the end of the study, 38% of the preservice teachers in the EG and only 5% of the students in the CG had "informed" views related to this aspect. "Difference between observation and

inference" is one of the aspects that most change is seen. Preservice teachers in the EG stating "informed" views have shown an increase of 33% in the posttest. At the same time, it is understood that a larger number of preservice teachers in the EG with 9 individuals stating "inadequate" views in the pretest and "informed" views in the posttest was in this aspect. In addition, it is seen that preservice teachers in the EG talked about the aspect of "observation-inference" when their worksheets in "Tricky Marks" activity were examined. A related example:

> Although we looked at the same data in this event, we have made different inferences. Because what everyone sees is not the same. Everyone has a different lifestyle and imagination. (E–40)

Distinction between Theory and Law

Related to this NOS aspect, 48% of preservice teachers in the EG and 46% of those in the CG mentioned "inadequate" views. There is only one preservice teacher holding "informed" views in each of the experimental and comparison groups in the pretest. At the end of the study, the number of preservice teachers increasing from "inadequate" views to "informed" views was one in the CG whereas three in the EG. On the posttest, 76% of preservice teachers in the EG reported "informed" or "adequate" views and in general most of the participants in both groups hold "adequate" views. The reason of preservice teachers holding mostly "adequate" views stems from the idea of saying "theory and law" are two different knowledge types while law is unchangeable. An example of this statement:

> There is of course a difference between theory and law. Theory is tentative knowledge whereas law is a definite knowledge. Evolution is a theory while gravity is a law. (C–41)

Preservice teachers in the CG mentioned about this NOS aspect in the worksheet for the activity named "Albert Einstein: Great Science Genius". For instance:

> Even the theory founded by Einstein can be changed. This means that there is no such a thing that theories become laws with time. (C–25)

Inferential Statistics

Table 3 and 4 show the results of Wilcoxon signed ranks test related to pretest and posttest distributions of experimental and comparison groups' preservice teachers' views about all aspects of NOS.

Table 3. Wilcoxon Signed Ranks Test Results of the EG

NOS Aspect	Ranks	N	Mean Rank	Sum of Ranks	z	p
Empirically Based	Negative	3	12.83	38.50	-2.36	.02*
	Positive	16	9.47	151.50		
	Ties	23				
Tentative	Negative	1	10.00	10.00	-4.03	.00*
	Positive	20	11.05	221.00		
	Ties	21				
Imaginative-Creative	Negative	1	8.50	8.50	-3.58	.00*
	Positive	16	9.03	144.50		
	Ties	25				

Subjectivity	Negative	4	14.00	56.00	-3.88	.00*
	Positive	25	15.16	379.00		
	Ties	13				
Observation-Inference	Negative	1	9.50	9.50	-4.49	.00*
	Positive	26	14.17	368.50		
	Ties	15				
Theory and Law	Negative	5	11.00	55.00	-2.96	.00*
	Positive	19	12.89	245.00		
	Ties	18				

According to Table 3 formed for the third sub-problem of this study, there are statistically significant ($p<.05$) differences between the EG's preservice teachers' views related to all aspects of NOS before and after intervention. Considering mean rank and sum of ranks of difference scores, it is seen that these observed differences are in favor of positive ranks or posttest.

Table 4 prepared for the fourth sub-problem of this study shows the results of Wilcoxon signed ranks test of preservice teachers' views related to all NOS aspects before and after intervention. Accordingly, it is understood that there are no statistically significant ($p> .05$) differences.

Table 4. Wilcoxon Signed Ranks Test Results of the CG

NOS Aspect	Ranks	N	Mean Rank	Sum of Ranks	z	p
Empirically Based	Negative	5	5.20	26.00	-.43	.67
	Positive	4	4.75	19.00		
	Ties	32				
Tentative	Negative	7	8.00	56.00	-.26	.80
	Positive	8	8.00	64.00		
	Ties	26				
Imaginative-Creative	Negative	10	9.90	99.00	-.17	.86
	Positive	9	10.11	91.00		
	Ties	22				
Subjectivity	Negative	7	11.00	77.00	-1.80	.07
	Positive	15	11.73	176.00		
	Ties	19				
Observation-Inference	Negative	2	4.00	8.00	-1.81	.07
	Positive	7	5.29	37.00		
	Ties	32				
Theory and Law	Negative	8	10.00	80.00	-1.04	.30
	Positive	12	10.83	130.00		
	Ties	21				

Table 5 and 6 show the results of Mann-Whitney test related to pretest and posttest distributions of experimental and comparison groups' preservice teachers' views about NOS aspects.

Table 5. Mann Whitney Test Results of Pretest Related to NOS Aspects

NOS Aspect	Group	N	Mean Rank	Sum of Ranks	z	p
Empirically Based	E	42	42.90	1802.00	-.53	.60
	C	41	41.07	1684.00		
Tentative	E	42	41.05	1724.00	-.51	.61
	C	41	42.98	1762.00		
Imaginative-Creative	E	42	41.62	1748.00	-.17	.86
	C	41	42.39	1738.00		
Subjectivity	E	42	48.73	2046.50	-2.92	.00*
	C	41	35.11	1439.50		
Observation-Inference	E	42	45.33	1904.00	-2.17	.03*
	C	41	38.59	1582.00		
Theory and Law	E	42	41.74	1753.00	-.11	.91
	C	41	42.27	1733.00		

According to the analysis results in Table 5 prepared for the fifth sub-problem of the study, there are no statistically significant differences between experimental and comparison groups' preservice teachers' views about NOS aspects of "empirically based", "tentative", "imaginative-creative" and "theory-law". However, there are statistically significant differences for NOS aspects of "subjectivity" and "observation-inference". These statistical differences in two of the aspects of NOS are in favor of the students in the EG.

Table 6. Mann Whitney Test Results of Posttest Related to NOS Aspects

NOS Aspect	Group	N	Mean Rank	Sum of Ranks	z	p
Empirically Based	E	42	48.86	2052.00	-3.29	.00*
	C	41	34.98	1434.00		
Tentative	E	42	50.07	2103.00	-3.54	.00*
	C	41	33.73	1383.00		
Imaginative-Creative	E	42	48.76	2048.00	-3.04	.00*
	C	41	35.07	1438.00		
Subjectivity	E	42	52.42	2201.50	-4.29	.00*
	C	41	31.33	1284.50		
Observation-Inference	E	42	52.99	2225.50	-4.68	.00*
	C	41	30.74	1260.50		
Theory and Law	E	42	46.31	1945.00	-1.89	.06
	C	41	37.59	1541.00		

According to Mann-Whitney test, there is a statistically significant difference between experimental and comparison groups' preservice teachers' views about five of the all NOS aspects in the posttest except from the aspect of "theory and law". As seen from Table 6 prepared for the sixth sub-problem of this study, these differences in five of the aspects of NOS are in favor of the preservice teachers in the EG.

Discussion and Conclusions

The purpose of this study was to explore the influence of NOS activities based on explicit-reflective and historical approach on preservice elementary teachers' views of NOS by minimizing the internal validity threats in the study. Maturation, subject characteristics, instrumentation, mortality, location, and testing were the possible threats to the internal validity of this work. The researchers tried to take some measures to control the internal validity threats throughout the study. They were

tried to be controlled with the research design of this work, three-week treatment period and by standardizing the procedures and conditions. Furthermore, observation checklists were used to control whether students' characteristics, instructors' characteristics, and physical properties of the classes were similar. And also it was assumed that the students in the experimental and comparison groups were not affected by each other.

More than half of the preservice teachers in both groups held "adequate" and "inadequate" views related to the investigated six aspects of NOS at the beginning of the study. Thus, it was understood that these students did not have a modern understanding of NOS. Moreover, the number of the participants in "informed" category was very few. This result was consistent with the findings of the researches (Abd-El-Khalick & Akerson, 2004; Abd-El-Khalick et al., 1998; Ayvacı, 2007) conducted in the literature evaluating preservice teachers' views about NOS.

According to results for the third sub-problem of this study, there were statistically significant differences between pretest and posttest distributions of the EG's preservice teachers' views related to all aspects of NOS in favor of posttest. Hence, it was comprehended that the explicit-reflective based NOS teaching was effective in enhancing preservice teachers' modern NOS views. In these six aspects of NOS, the largest change in the direction of good (the number of positive increases is being greater than the number of negative increases) was seen in "observation-inference". It was concluded that the difference between the number positive increases and negative increases was lowest in "empirically based" aspect. Thus for this study, it can be said that the activities prepared by explicit-reflective approach operated relatively best in "observation-inference" aspect.

According to results for the fourth sub-problem of this study, there were no statistically significant differences between pretest and posttest distributions of the CG's preservice teachers' views related to all aspects of NOS. But in the four of the six NOS aspects investigated, the number of preservice teachers with positive increases was higher than the negative growths. The number of preservice teachers with negative increases was more than positive growth with one person in the aspects of "empirically based" and "imaginative-creative". Within these four aspects maintaining more positive increases, the biggest differences were formed in the aspects of "subjectivity" and "observation-Inference". And it was figured out that proportionally (positive/negative) the largest increases in both groups occurred in "observation-inference" aspect. Consequently, it can be expressed that the activities prepared for this study worked better in terms of this aspect.

When the results for the fifth and sixth sub-problems of this study at first and all the data in general were examined, it was understood that explicit-reflective approach was more effective than historical approach. Preservice teachers' views of NOS aspects were positively increased in the group where students were administered NOS activities based on the explicit-reflective approach. Although a slight overall increase was observed in the views of preservice teachers' in the group to which NOS activities based on historical approach was applied, there were no statistically significant changes. This result of the study was also supported by the researches indicating the effectiveness of the explicit-reflective approach in the literature (Bell et al., 2011; Khishfe & Abd-El-Khalick, 2002).

If it is needed to discuss the findings of the research examining NOS aspects in individual order for the first and second sub-problems, it should be noted that more than half of the preservice teachers' in both groups had "inadequate" views about NOS aspect of "empirically based nature of scientific knowledge" before intervention. In the explicit-reflective approach implemented group, more than half of the preservice teachers still had "inadequate" views about this NOS aspect after the application. However, the number of preservice teachers in the "informed" category has increased. In this context, Khishfe & Abd-El-Khalick (2002) have made a study with 62 sixth grade students. They applied explicit-reflective approach based activities to one group and administered implicit based activities to the other group. In the explicit-reflective approach applied group, they found that there were pretty much students having "inadequate" views about "empirically based" NOS even after intervention. Hence, Khishfe & Abd-El-Khalick (2002)'s findings were consistent with the results of this study. In the historical approach used group, it was observed that there were no significant

changes in preservice teachers' views of this NOS aspect. The possible causes of little change in all students' views of "empirically based" NOS and five of the participants previously in "informed" category ended in "inadequate" category could be sourced from the activities or study in general. But this might also be a reflection of the education preservice teachers were subject to for many years. It was also considered that the reason of encountering such a resistance might be due to serving information to students always ready for many years and obtaining information directly without search for any evidence.

Another finding of the study has revealed that preservice teachers in both groups mostly had "adequate" views about "tentative" NOS before the application. There were no preservice teachers having "inadequate" views about "tentative" NOS in the EG after the implementation. In the literature, it was also found that "tentative" NOS aspect can be developed quickly (Abd El Khalick & Akerson, 2004; Leblebicioğlu et al., 2012; Morrison, Raab, & Ingram, 2009). There was no change in the CG's preservice teachers' views after the implementation. Abd-El-Khalick and Lederman (2000)'s findings were also consistent with the results of this study.

In this study, it was seen that preservice teachers in both groups accept the role of "imaginative and creativity" in the pretest, but on this issue more than half of them stated "adequate" views. In the EG, "informed" views have increased after the implementation. However in the CG, the number of preservice teachers in the "informed" category decreased. Another important point should be noted that there were preservice teachers having "inadequate" views in the pretest but increased to "informed" views at the posttest. In the literature, there were studies (Abd-El-Khalick, 2001; Akerson et al., 2000) saying that explicit-reflective approach was effective on this NOS aspect. There were also studies (Beşli, 2008) telling that historical approach was effective or on the contrary not that much effective (Abd-El-Khalick & Lederman, 2000) on this aspect of NOS.

One of the results of the study has shown that preservice teachers' views related to "subjectivity" of NOS varied in the pretest. More than half of the students in the EG reported "adequate" views in the pretest, whereas also more than half of the individuals in the CG stated "inadequate" views in the pretest. In the posttest, nearly half of the preservice teachers in the EG were in "informed" category, while it was observed that there were very few students in this category in the CG. Ultimately, explicit-reflective approach has been effective in developing preservice teachers' views of "subjectivity" of NOS. In the literature, there were some studies that support this conclusion (Bell et al., 2011). Few studies contradicting with this result of the study were also reported in the literature (Akerson et al., 2000).

The number of preservice teachers having "informed" views was least in "distinction between observation-inference" and "distinction between theory and law" aspects of NOS. It was seen that preservice teachers' views about "distinction between observations and inferences" collected in the category of "inadequate" for both groups. It was also found in the literature that "the difference between observation and inference" aspect of NOS was unknown by most of the preservice teachers (Abd-El-Khalick, 2005; Küçük, 2008). After the intervention, it was concluded that explicit-reflective approach has been effective in increasing preservice teachers' views about "distinction between observations and inferences". The change in the EG was at most in this NOS aspect. In a study conducted by Abd-El-Khalick and Akerson (2004), it was reported that 25% of preservice teachers had "adequate" views about "observation-inference" of NOS before the application. This proportion rose to 75% at the end of the work. These results were consistent with the results of this study.

At the end of the study, the only NOS aspect that no significant difference was found between the EG and CG was "distinction between theory and law". Preservice teachers in both of the groups were trained with textbooks including the misconception of hierarchical structure in "theory and law" (Irez, 2009; McComas, 2008). Although there was no statistically significant difference between groups, an increase occurred in the EG. Despite having the same number of "informed" views in the CG after the intervention, this number has increased in the EG. Preservice teachers often said that the theory could change, but not the law. In the literature, it was found that this idea was widely occurred

and difficult to change (Abd-El-Khalick, 2005; Akerson, Morrison, & McDuffie, 2006). In addition, preservice teachers also stated that there was a hierarchical structure between the theory and the law. In a study conducted with 19 preservice teachers, Akerson et. al. (2006) reported that all the preservice teachers did not know the distinction between "theory and law" and they thought that theories will change to law when they are proofed.

Implications

- The development of different activities to teach NOS with a larger sample of students, preservice teachers and teachers is recommended.
- Making more long-term studies and increasing the number of activities is offered.
- It is suggested that activities used in studies are better to be designed according to NOS aspects that are more difficult such as the distinction between theory and law.
- There are many studies that compared with the explicit-reflective approach and conventional method and stated the effectiveness of explicit-reflective approach. Therefore, more experimental studies in which internal validity threats are more closely controlled and explicit-reflective approach is compared with the other two or three approaches are required.
- In the activities based on the historical approach to develop "imagination and creativity", it may be more useful to apply activities that students produce something besides students only write.
- Experimental or mixed method researches between groups by using explicit-reflective approach and groups by employing historical approach models or ways different from this study can be done.

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Appendix

Contents of the Activities Utilized in Groups

Group	Name	Materials	Common NOS Aspects	Common Aims
E	Tricky Marks	Three figures shown, worksheets	* Empirically Based * Tentative * Imaginative-Creative * Subjectivity * Observation-Inference * Theory and Law	* To understand the difference between inference and observation * To recognize the large number of answers based on the same evidence about the same question would be valid to the same extent * To realize the observation made by many people could increase the accuracy of the results more * To recognize how personal and cultural experiences and prejudices affect a person's implications about observations * To realize a person's past experiences affect his/her interpretation of observations and this situation could take him to the unscientific results
E	Magic Pipe	Toilet paper rolls, laundry rope, scissors, paper clips, worksheets		
E	Water Generator	1 liter plastic box, 1 m plastic pipe, silicon, large funnel, 250 ml of leveled beaker, water, 500 ml of water container, cone, large box, worksheets		
C	Archimedes: "I found it, I found it!" (287–212 BC)	A text about the life of Archimedes		
C	Marie Curie: Woman died for science (1867–1934)	A text about the life of Marie Curie		
C	Albert Einstein: Great science genius (1879–1955)	A text about the life of Albert Einstein		