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The Effect of Project-Based History and Nature of Science Practices on the Change of Nature of Scientific Knowledge

Ayşe Sert Çıbık
Gazi University, Gazi Education Faculty, Ankara, TURKEY

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The aim of this study is to compare the change of pre-service science teachers' views about the nature of scientific knowledge through Project-Based History and Nature of Science training and Conventional Method. The sample of the study consists of two groups of 3rd grade undergraduate students attending teacher preparation program of science education at an education faculty in Turkey. In this study, in which quantitative and qualitative research methods are used, non-equivalent control group design out of quasi-experimental designs is employed. Student Understanding of Science and Scientific Inquiry questionnaire is applied to both groups as pre-test and post-test. After the applications, a significant difference is observed to be in favor of the experimental group and they mostly described their views as Transitional Views and Informed Views whereas the control group defined their views as Transitional Views and Naïve Views. Carrying out the History and Nature of Science course through project activities is found to be useful, and performing the course with activities oriented towards the projects is recommended by pre-service teachers.

Keywords: history and nature of science, nature of scientific knowledge, pre-service science teacher, project-based learning

INTRODUCTION

Although scientific knowledge features many definitions in its context, it is generally referred to as social and cultural values of science, and values and beliefs regarding scientific knowledge (Lederman, 1992; Roth & Roychoudhury, 2003). The social aspect of science has a role of forming the society and revealing many questions waiting for the answers regarding how the society views the nature of science (Ryder, Leach, & Driver, 1999). Internalizing the nature of science (NOS), to a large extent, matters greatly in terms of being scholarly literate. In other words, this concept involves knowing the features of scientific knowledge and scientists, holding views about scientific events in all the fields and recognizing the dynamic relation between science and society (Driver, Leach, Millar, & Scott, 1996). Previously NOS was associated with scientific process skills, however, it is currently more related to values, views and beliefs (Lederman & Zeidler, 1987). This situation requires doing more detailed research on the notions examined within the scope of

Correspondence: Ayşe Sert Çıbık
Gazi University, Gazi Education Faculty, Beşevler, 06500, Ankara, TURKEY
Email: sertcibik@gmail.com
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scientific knowledge (law, theory, observation, argument, scientific method, socio-cultural values etc.) together with featuring the changing structure of scientific knowledge. Although there are still many debates on NOS, philosophers, historians, sociologists and science educators have arrived at a consensus on the basic aspects of NOS as a result of the research studies they have carried out (Abd-El-Khalick, Bell, & Lederman, 1998; Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002; McComas & Olson, 1998). Unfolding the theoretical structure of the descriptions of these dimensions and the relations among them is certain to give detailed information about the nature of scientific knowledge.

There have recently been many national studies (Ayvacı & Er Nas, 2010; Doğan Bora, Arslan, & Çakıroğlu, 2006; Gürses, Doğar, & Yalçın, 2005; Taşar, 2003) and international studies (Abd-El-Khalick & Lederman, 2000; Bell, Lederman, & Abd-El Khalick, 2000; Lederman, 1992; Lederman, 2007; Moss, 2001; Zeidler, Walker, Ackett, & Simmons, 2002) on NOS, which is a popular field of study. The common result of these study findings is that both teachers on duty and students at all educational levels (primary, secondary, high school, university) have some shortcomings in understanding NOS. When it is departed from the idea that especially teachers have diverse views on NOS, teaching methods and techniques that each teacher brings to the class are affected from this situation (Driver et al., 1996). In addition to this, the perceptions of teachers into NOS and their classroom practices affect students' views of science. Therefore, it is primarily necessary for teachers to think as scholarly literate and to have enough information about NOS (Lederman et al., 2002; Ryan & Aikenhead, 1992). The most important steps on this issue are teachers' understanding of science and nature of scientific knowledge correctly and transmitting these into their students through appropriate methods and techniques in classroom practices (Küçük, 2006; Tuan & Chin, 1999). By this means, it could be possible to train science literate students who can learn science by doing science and discover NOS by his/her own experiences.

One of the primary aims of science education is to develop students' and even teachers' beliefs of NOS (Kang, Scharmann, Noh, & Koh, 2005). Nowadays, teachers unfortunately cannot go beyond giving examples of scientific knowledge in theory and practice in science courses. In addition to this action, students need to become aware of NOS and there needs to be an understanding about how scientific knowledge is formed and which phases it completes to develop (Crowther, Lederman, & Lederman, 2005; Schwartz, Akom, Skjold, Hong, Kagumba, & Huang, 2007). Bringing students' cognitive, affective and psychomotor skills into action through such an attitude could enable the students to understand NOS better (Sert Çıbık, 2014). Students need to be enlightened through examples about how and why the subjects in science courses change until today as new theories and laws are set forth (Crowther et al., 2005; Çakıcı, 2009). For instance, there used to be 9 planets in the space as mentioned in textbooks, magazines and encyclopedias in the past and Pluto was accepted as the smallest one. However, many researchers currently study on clarifying the description of planet as Pluto is rather a dwarf planet (Doğan, Çakıroğlu, Bilican, & Çavuş, 2009). That is, instead of presenting today's "planet" concept as it has been, students need to be informed in details about different views on this issue suggested previously and why Pluto is now a dwarf planet after 76 years. By means of such an approach, it would be possible to actualize more meaningful and permanent learning about "planet" concept, which forms a part of NOS.

In consequence, developing required strategies about the content of NOS and teaching its importance to teachers raising the future generations are considered to be important In order to realize this, different methods and techniques (project, analogy, discussion, trip, observation) prompting students to do research are supposed to be used instead of traditional methods while searching for the nature of scientific knowledge about the subjects of science courses. The existence of various studies in literature supporting these kinds of action has had an effect upon carrying out the current study (Lederman, 1992; Lederman & Lederman, 2004; Schwartz et al., 2007).

Implicit approach, one of the instructional approaches employed in teaching NOS, is based on the anticipation that 'students can positively improve their views about NOS through their active participations in scientific activities' (Lawson, 1982). In this approach, it is believed that the nature of scientific knowledge can develop automatically as training practices focusing on research-inquiry process and scientific process skills are actualized (Lawson, 1982; McComas, 1993). The approach in Project-Based Learning (PBL) process is the one in which the information is acquired at first-hand, students can reach the information by themselves, the information is transferred into the related areas easily, research-inquiry is carried out in depth and the information acquired with the help of scientific process skills is presented by being gathered in an appropriate way (Demirhan, 2002). This characteristic of PBL indicates that implicit approach could be used in learning the nature of scientific knowledge. Mostly, descriptive survey studies stand out in the related literature. The views of the participants (students/students, teachers/teachers) regarding the nature of scientific knowledge in these studies are gathered through open-ended, multiple choice questions and questionnaires (Abd-El-Khalick et al., 1998; Lederman, 1992; Lederman, Lederman, & Antink, 2013; Taşar, 2006). On the other hand, while there are empirical studies (Abd-El-Khalick & Akerson, 2004; Doğan, Çakıroğlu, Çavuş, Bilican, & Arslan, 2011; Küçük, 2006; Morgil, Temel, Güngör Seyhan, & Ural Alşan, 2009; Önen, 2013; Özgelen, 2010; Schwartz, Lederman, & Crawford, 2004) in the related literature, the motivation behind the current study has been the lack of project-based practices. In this context, Project-Based History and Nature of Science (PBHNOS) training employed in this study is believed to have importance in terms of contributing positively to the views of pre-service science teachers about the nature of scientific knowledge and giving applicable recommendations for further research on this field. As a result of the assertions above, the main reason underlying the present study is to reveal how pre-service science teachers perceive the History and Nature of Science course included recently in teacher preparation programs and to what extent they are aware of the issue whether the developments in science get affected from psychological, historical, sociological and philosophical aspects. Moreover, it is aimed to see the effects of the PBL method, which motivates students towards multifaceted research in terms of scientific process skills, on the change of this specified situation.

The aim of the study

The aim of this study is to compare the change of pre-service science teachers' views about the nature of scientific knowledge with PBHNOS training and Conventional Method (CM). In accordance with this main aim, the following research questions seek answers.

1. *Is there any significant difference between the pre-test/post-test SUSSI scores of the experimental and control groups?*
2. *What is the distribution of answers given to the open-ended questions of SUSSI questionnaire in the pre-test/post-test of the experimental and control groups?*
3. *What are the views of the participants in the experimental group about the method after the treatment?*

METHOD

Research design

In this research, the data obtained from Student Understanding of Science and Scientific Inquiry (SUSSI) questionnaire is evaluated both quantitatively and qualitatively. That is, quantitative method has been employed as Likert-scale items in order to gather the views of pre-service teachers about the nature of scientific knowledge. On the other hand, qualitative method has been applied for assessing the answers given to the open-ended questions.

"Non-equivalent control group design" out of quasi-experimental designs, which is one of the experimental designs, is used in the present study. *"Non-equivalent control group design",* which is known as specifying one randomized control group and one randomized experimental group from the universe, is often used in research studies. In this design, the participants in the groups are measured in terms of dependent variable(s) before the treatment. While the experimental group is instructed through the experimental method, the effect of which is being tested in the treatment process, the control group does not receive the same training. After the treatment, the same test is used to gather the results of the groups related to dependent variable(s) (Karasar, 2004, 102; Kenny, 1975). The research design of this study is summarized in Table.1.

Sample of research

The study comprised two groups of 3rd grade undergraduate students attending teacher preparation Program of Science Education at Gazi University Gazi Faculty of Education in the spring semester of 2013-2014 academic year. One of the groups chosen randomly was determined as the experimental group (N:41) and the other random group was the control group (N:46).

The content of the teaching methods in the research

This study was conducted in History and Nature of Science course which is scheduled in the second semester of the 3rd grade at Science Education Department. In order to test the change of the pre-service teachers' views about the nature of scientific knowledge, the subjects in the course were instructed through two different teaching methods. In this sense, while the experimental group was instructed through PBL, the control group received CM.

Project-based history and nature of science training

PBHNOS training was carried out by teaching the subjects in the course syllabus through project activities including the practice steps of PBL in addition to the techniques such as discussion, question-answer, brainstorming on the change of pre-service teachers' views about the nature of scientific knowledge. In the training

Table 1. Research Design

Group	Pre-test	Instruction	Post-test
Experimental group	T_1	PBHNOS	T_1, T_2
Control group	T_1	CM	T_1

T_1: Student Understanding of Science and Scientific Inquiry (SUSSI)
T_2: The Questionnaire Form

process (14 weeks) during the semester, project activities involving the practice steps of PBL method were performed in the experimental group depending on the subjects in the course syllabus. Detailed course syllabus for the project practices in which the phases mentioned before are taken into account is included in Appendix 1.

Conventional method

The subjects in the syllabus of the course were instructed via techniques such as traditional lectures, discussion, question-answer and brainstorming on the change of pre-service teachers' views about the nature of scientific knowledge. In this training conducted with the control group during a whole semester (14 weeks), the subjects in the syllabus of the course (same order of the subjects as in the experimental group) were taught by the researcher through concrete examples and activities mostly including discussions and brainstorming, and then the treatment process was completed.

Data collection instruments

SUSSI questionnaire

There exist many research studies in the literature aiming to find out the views of students at all educational levels about NOS (Chen, 2006; Lederman et al., 2002; Zeidler et al., 2002). Some of these studies employ data collection instruments based on quantitative analysis and some others depend on qualitative analysis. Quantitative analysis procedure for NOS has been critiqued as there seems to be a gap between the researchers' interpretations of the findings and the students' actual answers to the items. Moreover, it has the disadvantage for researchers as they do not find the opportunity to notice this gap between the interpretations as a result of the design of these data collection instruments (Lederman, 2007). On the other hand, qualitative analysis procedure for NOS provides more detailed information about the views of students on NOS to the researchers (Hacıeminoğlu, 2013). However, qualitative instruments have some difficulties for researchers as their interpretation and administration could be time consuming. This structure of qualitative data collection instruments makes them difficult to conduct with large groups and the participants may not be capable of expressing their opinions and feelings in a proper and effective way (Liang, Chen, Chen, Kaya, Adams, Macklin, & Ebenezer, 2006; Lederman, 2007).

As a result of the drawbacks of the both methods, the combination of quantitative and qualitative methods has been advocated in this study to reap the benefits of two paradigms and to hinder the researchers' misinterpretations of the findings (Greaves-Fernandez, 2010; Hacıeminoğlu, Yılmaz-Tüzün, & Ertepınar, 2014). Moreover, it is essential for the results to be quantifiable as it is targeted to compare the views of the participants between the groups and pre- and post-tests. SUSSI test (Liang, Chen, Chen, Kaya, Adams, Macklin, & Ebenezer, 2008) has been chosen as the data collection instrument of this study to find out the views of the pre-service science teachers on NOS since it mixes qualitative and quantitative approaches and gathers quantifiable data. SUSSI combines Likert-scale items and related open-ended questions to determine pre-service science teachers' views regarding the nature of scientific knowledge development with respect to six elements. There are four Likert-items in each part of the questionnaire including informed, transitional and naïve ideas and one open-ended question. The questionnaire comprises of 24 Likert-scale items and six open-ended questions in total (Liang et al., 2008).

The questionnaire is prepared on the Likert-scale (from 1 to 5) with 1 indicating *strong disagreement* and 5 indicating *strong agreement*. Accordingly, the highest score that can be obtained in quantitative data is 120 and the lowest is 24. Also, a scoring guide is prepared for the analysis of the student-constructed responses given to the open-ended questions. If a response is accordant with the contemporary thought on NOS, it is found as an *informed views* (score="3"). *Transitional views* (score="2") represent the responses that are partially informed views or fail to provide reasons for justification. Responses including misunderstandings or self-contradictory expressions are evaluated as *naïve views* (score="1"). Lastly, the following situations are rated as *not classifiable* (NC) if: no response is given; the participants state that they do not know; the response does not refer to the question; or, the response cannot be rated according to checklist instructions (Liang, Chen, Chen, Kaya, Adams, Macklin, & Ebenezer, 2009).

Validity and reliability analyses of SUSSI

SUSSI was first carried out with American pre-service teachers, and validity and reliability measures have been maintained. It was later translated into Chinese and Turkish and hereby conducted with Chinese and Turkish participants. No fewer than two bilingual science education researchers (native speakers of Chinese or Turkish with a PhD degree in science education and fluent in English) translated the questionnaire into these languages and then debated over each item and finally settled the controversies in the translated drafts in order to provide precision and equality between the translations (Liang et al., 2009).

The validity and reliability of the findings obtained from the questionnaire are of capital importance as the sampling is composed of Turkish students. Therefore, validity and reliability checks have been rehearsed for this study so as to apply it to the pre-service science teachers.

In the validity analysis procedure of the questionnaire, following steps are pursued:

- The questionnaire, originally in English, was translated into Turkish by an expert having a good command of English, and the translation was checked by a linguist and they reached a common ground on the expressions differing from each other. The draft Turkish form created through completing these phases was retranslated into English. The original English version of the questionnaire and the retranslated version were examined by a linguist and it was concluded that there was no discrepancy between two forms.
- After determining the feasibility of Turkish version of the questionnaire, construct validity was maintained thanks to the views of experts on science education and it was accepted as applicable in terms of translation.
- Finally, the questionnaire was pilot-tested on eight pre-service science teachers in order to see the intelligibility of the items. The items were found to be clear as a result of their responses. This version of the questionnaire was found in conformity with original Turkish form (Liang et al., 2006).

The questionnaire, ensuring the translation and construct validity with these steps, maintained the validity measurement and following phases were pursued for the reliability analysis.

In order to measure the reliability of the questionnaire, the Cronbach Alpha method was used for the internal reliability. For this reason, the questionnaire was administered to thirty-two pre-service science teachers attending Gazi University Faculty of Education Science Education Department. For Cronbach Alpha values of internal reliability related to the overall questionnaire and aspects which have been analyzed via SPSS-11.5, see Table 2 below.

All these analyses have indicated that the questionnaire, which was retranslated into Turkish for this study, is sufficiently valid and reliable for finding out the views of pre-service teachers about the nature of scientific knowledge.

The questionnaire form

A questionnaire was developed to reveal the pre-service science teachers' views regarding PBL practices. The aim of this questionnaire is to support the quantitative data gathered in the research. Therefore, the questionnaire was administered to all the participants (N:41) in the experimental group after the post-test. 3 different items including various student views about the PBL activities performed in the course were involved in the questionnaire developed by the researcher and there were also judgments showing their agreement or disagreement with them. One open-ended question as in the format "please explain the reason of your response shortly" was placed following these items.

In the process of developing the questionnaire form, the research studies in the literature were examined and a questionnaire with 7 items was prepared according to the findings of these studies. The face validity of the questionnaire items was consulted with three experts on science education. In accordance with the views gathered from the experts, necessary regulations were performed on the questionnaire and 4 items serving for the same purpose were removed from the questionnaire. Moreover, the questionnaire was examined by experts for the sake of the consistency of the items in terms of language use and meaning. As a result of the reviews, the items were judged as sufficiently clear. The responses given to 3 open-ended items in the questionnaire were analyzed descriptively.

Data analysis

As this study is guided by 3 main research problems, the data have been analyzed both quantitatively and qualitatively according to the sub-problems related to these main problems.

Quantitative data analysis

SPSS-11.5 was employed for the analysis of the data gathered from the SUSSI questionnaire. For the analysis of the data, frequency (f)-percentage (%) and independent samples t-Test out of descriptive statistics were used. "N" seen in tables refers to the total number of students.

Table 2. Cronbach Alpha Values of Internal Reliability for SUSSI Questionnaire and Its Aspects

SUSSI target aspects	**Reliability (Cronbach Alpha)**
Observations and inferences	0.64
Tentativeness	0.62
Scientific theories and laws	0.67
Social and cultural embeddedness	0.68
Creativity and imagination	0.63
Scientific methods	0.66
Overall questionnaire (24 Likert items)	0.67

Qualitative data analysis

Descriptive analysis method was utilized for the qualitative aspect of the research. Student-constructed open-ended responses were scored using the SUSSI questionnaire rubric given by Liang et al. (2009). The reason to use the rubric was to analyze the consistency between the student-constructed responses to the Likert items. On the other hand, the responses given to the questionnaire form aiming to reveal the pre-service science teachers' views about PBL practices were analyzed through short codings and frequency (f)-percentage (%) values related to these codes.

FINDINGS

The findings obtained from the sub-problems of the research are as follows:

Is there any significant difference between the pre-test/post-test SUSSI scores of the experimental and control groups?

The analysis of the pre-service science teachers' views towards the nature of scientific knowledge before and after the treatment was performed through independent samples t-Test. For the findings, see Table 3 below.

It is clear from the mean scores of the overall questionnaire that the mean score of the control group is higher than the experimental group's score. Therefore, one can conclude that there is a significant difference in favor of the control group [$\bar{X}_{(control)}$=84.98]. When the SUSSI is evaluated in terms of the aspects, significant differences could be seen in the scores related to 'scientific theories and laws' and 'social and cultural embeddedness' and this difference is in favor of the control group [$\bar{X}_{(control)}$=11.50, $\bar{X}_{(control)}$=13.50]. The mean scores related to the overall questionnaire indicate that the mean score of the experimental group is higher than those of control group. That is to say, this significant difference is in favor of the experimental group [$\bar{X}_{(experimental)}$=103.10]. The evaluation of the SUSSI aspects shows that there is a significant difference among the scores related to all the aspects and this difference is in favor of the experimental group. These results can be interpreted as PBL method has become effective in changing the views of teachers towards NOS in a positive way.

What is the distribution of answers given to the open-ended questions of SUSSI questionnaire in the pre-test/post-test of the experimental and control groups?

The distribution of the responses given to the open-ended questions in the SUSSI questionnaire in the pre-test/post-test of the experimental and control groups is analyzed through frequency(f)-percentage(%) out of descriptive statistics within the categorization of NC: Not Classifiable, NV: Naïve Views, TV: Transitional Views and IV: Informed Views and the results are presented in Table 4.

As a result of these findings (pre-test open-ended questions of the questionnaire), it can be claimed that the distribution of participants' overall scores is close to each other and their opinions towards the items are similar. When the general evaluation is performed related to the aspects of the questionnaire, most of the participants' opinions towards the items in the questionnaire are categorized under NC and NV and they have a similar distribution in these categories. On the other side, it is also remarkable that they have quite a few views regarding TV categorization and no ideas in IV categorization. .

The evaluation of the findings (pro-test open-ended questions of the questionnaire) shows that the experimental group has positively improved their views on the nature of scientific knowledge in TV and IV categories and they have converted their knowledge about it into well-informed. On the other hand, the views of the control group towards the nature of scientific development take place in NV and TV categories. In accordance with this general finding, one can claim that the participants in the experimental group have positively restructured their views towards the nature of scientific knowledge after the PBHNOS training and they have

Table 3. Descriptive Statistical Values of SUSSI Pre-Test/Post-Test Scores and Independent Samples t-Test Results

SUSSI target aspects	Pre-test									Post-test								
	Experimental			Control						Experimental			Control					
	N	$\bar{X}$	sd	N	$\bar{X}$	sd	t	df	p	N	$\bar{X}$	sd	N	$\bar{X}$	sd	t	df	p
Observations and inferences	41	13.73	1.69	46	14.20	1.83	-1.22		.225	41	18.20	3.26	46	15.48	2.16	4.61		.000*
Tentativeness	41	16.78	2.01	46	16.63	2.24	.32		.745	41	18.34	2.87	46	15.43	2.41	5.11		.000*
Scientific theories and laws	41	9.12	2.13	46	11.50	1.79	-5.63		.000*	41	13.61	2.16	46	12.39	2.25	2.56		.012*
Social and cultural embeddedness	41	12.34	2.12	46	13.50	1.65	-2.84	85	.006*	41	17.32	2.91	46	15.28	2.91	3.25	85	.002*
Creativity and imagination	41	16.27	2.22	46	15.65	1.62	1.48		.141	41	18.41	2.25	46	13.98	3.10	7.58		.000*
Scientific methods	41	13.12	1.64	46	13.50	1.15	-1.25		.214	41	17.22	2.94	46	14.22	2.50	5.13		.000*
Overall questionnaire	41	81.36	5.45	46	84.98	4.65	-3.33		.001*	41	103.10	10.83	46	86.78	7.45	8.26		.000*

$p<.05$

Table 4. Descriptive statistic results of the SUSSI scores related to the responses of the open-ended questions

SUSSI target aspects	Pre-test																Post-test															
	Experimental								Control								Experimental								Control							
	NC		NV		TV		IV		NC		NV		TV		IV		NC		NV		TV		IV		NC		NV		TV		IV	
	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%
Observations and inferences	19	21.8	20	23.0	2	2.3	0	0	22	25.3	22	25.3	2	2.3	0	0	0	0	3	3.4	19	21.8	19	21.8	0	0	17	19.5	23	26.4	6	6.9
Tentativeness	15	17.2	24	27.6	2	2.3	0	0	21	24.1	22	25.3	3	3.4	0	0	1	1.1	3	3.4	19	21.8	18	20.7	0	0	18	20.7	23	26.4	5	5.7
Scientific theories and laws	18	20.7	22	25.3	1	1.1	0	0	18	20.7	26	29.9	2	2.3	0	0	0	0	3	3.4	20	23.0	18	20.7	0	0	18	20.7	22	25.3	6	6.9
Social and cultural embeddedness	17	19.5	23	26.4	1	1.1	0	0	23	26.4	21	24.1	2	2.3	0	0	0	0	0	0	21	24.1	20	23.0	0	0	16	18.4	26	29.9	4	4.6
Creativity and imagination	18	20.7	21	24.1	2	2.3	0	0	24	27.6	20	23.0	2	2.3	0	0	0	0	1	1.1	23	26.4	17	19.5	0	0	16	18.4	25	28.7	5	5.7
Scientific methods	22	25.3	17	19.5	2	2.3	0	0	19	21.8	26	29.9	1	1.1	0	0	0	0	2	2.3	18	20.7	21	24.1	0	0	21	24.1	22	25.3	3	3.4
Overall questionnaire	109	20.8	127	24.3	10	1.9	0	0	127	24.3	137	26.2	12	2.3	0	0	1	1.1	12	2.2	120	22.6	113	21.6	0	0	106	20.6	141	27	29	5.5

Table 5. Illustrative examples given to the open-ended questions according to the aspect of the SUSSI questionnaire (pre-test)

SUSSI target aspect	Pre-test			
	More naive views		More informed views	
	Experimental	Control	Experimental	Control
Observations and inferences 1. With examples, explain why you think scientists' observations and inferences are the same OR different.	There is only one answer for every question of the nature. Scientists should also reach the similar information in their observations and inferences. However, they can exceptionally come up with different findings as a result of the variety in their prior knowledge. S#31	While the observations may be the same when they are about the same issue, some observations and inferences may not be different as a result of the diversities based on the scientists' personal abilities. S#43	Two scientists can make observations and inferences if they are trained within the same conditions, levels and the prior knowledge. Yet, some factors such as individual differences, viewpoints, ability of inference, imagination and approach cause various observations and inferences of scientists. S#2	Scientists can make different comments about the same issue. Each scientist has a different system of thought, lifestyle and belief; salient findings in their observations can be interpreted in various ways. S#13

Table 6. Illustrative examples given to the open-ended questions according to the aspect of the SUSSI questionnaire (post-test)

SUSSI target aspect	Post-test			
	More naive views		More informed views	
	Experimental	Control	Experimental	Control
Observations and inferences 1. With examples, explain why you think scientists' observations and inferences are the same OR different.	The accuracy of scientific knowledge depends on the universality of observations and inferences. Because scientists' same interpretation for the same problem indicates the certainty of experiment findings. S#15	Need to be the same. Because the occurrence reason of any incident is the same and can be seen via only an observation. Accordingly, interpretations to be made need to be the same. This situation is related to the objectivity of scientists. S#4	Observations and interpretations of scientists are various. Because each scientist has a different social life, interest and prior knowledge. For instance, each scientist interprets the evolutionary theory in different ways according to his/her existing background knowledge and system of thought gained as a result of life experiences. S#16	Scientists can have different observations about the same issue. Because they differ in their research studies, creativity, prior knowledge, and abilities. For this reason, their interpretations may be different, too. S#15

Table 7. Coding of the qualitative data and frequency (%)-percentage (%) values

Items		Categories related to the items								
		Yes	f	%	No	f	%	Not sure	f	%
1. It has been beneficial to carry out History and Nature of Science course through research project activities	Coding	Recognizing the notions related to the course	11	26.83				Difficulty in resource procurement	2	4.87
		Discovering the practicality of NOS instructed through oral presentation	9	21.95				Having trouble in completing the project timely	1	2.43
		Gaining a different viewpoint	7	17.07						
		Acquiring new and different knowledge	5	12.19						
		Guiding	3	7.31						
		Doing research	2	4.87						
		Collaborative work	1	2.43						
Total			38	92.65		0	0		3	7.3
		Yes	f	%	No	f	%	Not sure	f	%
2. I recommend carrying out History and Nature of Science course through activities oriented towards the use of projects	Coding	Raising the interest in the course and permanent learning	10	24.39	Being time-consuming	3	7.31	Problems related to group work	3	7.31
		Eliminating misconceptions	7	17.07	Grade anxiety	2	4.87	Lack of research sources	2	4.87
		Gaining the steps of scientific process	6	14.63				Shortcomings in sharing the knowledge	1	2.43
		Gaining a different thinking ability	3	7.31						
		Ensuring meaningful learning by putting the knowledge into practice	2	4.87						
		Ensuring more accurate and detailed learning	2	4.87						
Total			30	73.14		5	12.18		6	14.61
		Yes	f	%	No	f	%	Not sure	f	%
3. Carrying out the History and Nature of Science course through project activities has positively affected my perspective related to the course	Coding	Making the course more fun and enjoyable	11	26.83	Fail to understand abstract concepts	4	9.75	Using verbal expressions frequently	3	7.31
		Enabling sophisticated thinking	8	19.51	Unfeasibility of project activities for this course	2	4.87			
		Arousing curiosity and interest	7	17.07						
		Facilitating learning	4	9.75						
		Imagination	2	4.87						
Total			32	78.03		6	14.62		3	7.31

mostly eliminated their existing fallacies. The evaluation of the aspects of the questionnaire presents that the experimental group has mainly reshaped their ideas on NOS in TV and IV categories. This finding matching up with the results obtained from the overall questionnaire indicates that the participants could correctly define their knowledge about the nature of scientific knowledge as a whole. The views of the control group on NOS generally take place in NV and TV categories.

What are the views of the participants in the experimental group about the method after the treatment?

Short coding of the responses given to 3 open-ended questions prepared by the researcher in order to find out pre-service science teachers' views towards PBL training and related frequency(f)-percentage(%) values are given in Table 7.

Moreover, for the comparisons of the pre-service teachers' responses given to the open-ended questions and illustrative examples, see Tables 5 and 6 respectively. These selected utterances from the participants' responses are verbatim extracts. These sample utterances categorized by themes and questions exemplify the views of the participants regarding the nature of scientific knowledge development (for example; observations and inferences).

The findings of the first item indicate that 92.65% of the pre-service teachers (f=38) replied as "Yes" and 7.3% (f=3) gave the response "Not sure". Consequently, it can be claimed that majority of the respondents think that carrying out the course, History and Nature of Science, via project activities is beneficial for them. The responses given to the second item were "Yes" by 73.14% of the participants (f=30), "No" by 12.18% of them (f=5) and "Not sure" by 14.61% (f=6). As a result, it can be asserted that majority of the pre-service teachers recommend carrying out the course History and Nature of Science via activities oriented towards the use of projects. The responses were determined as "Yes" by 78.03% of the pre-service teachers (f=32), "No" by 14.62% of them (f=6) and lastly "Not sure" by 7.31% of the participants (f=3) for the third item. To sum up, it could be conferred that performing the course via project activities have positively affected most of the pre-service teachers' views towards the History and Nature of Science course.

DISCUSSION AND CONCLUSIONS

It is possible to claim that the knowledge about the nature of scientific knowledge develops depending on some reasons although the pre-service teachers have been trained through similar traditional programs in the past. In other words, the effects of various factors such as prior knowledge about the nature of scientific knowledge, knowledge and experiences, environment and society, instructors, different methods and techniques etc. can differ in what a learner acquires. Before discussing these factors, which are effective in gaining scientific knowledge, one should explain what scientific knowledge is and how NOS is perceived.

The notion of NOS refers to the epistemology and sociology of science, and values and beliefs inherent in scientific knowledge (Lederman, 1992; Lederman & Zeidler, 1987). NOS, in general terms, emphasizes the epistemology of science and is a way of knowledge. It also includes values and beliefs existing in the core of scientific knowledge development (Abd-El-Khalıck et al., 1998). In this sense, NOS can be regarded as a way followed in realizing the scientific knowledge, and the relation among science-technology-society is at the forefront in this process. However, Abd-El-Khalıck et al. (1998) stressed that NOS and scientific procedures differ from each other although there is an interaction between these two concepts. As a result, it is a necessity to determine the role of education and training in the development of views towards the nature of scientific knowledge and how this notion is perceived and interpreted.

The related literature demonstrates that students at any age group (Doğan Bora et al., 2006; Kılıç, Sungur, Çakıroğlu, & Tekkaya, 2005; Lederman, Wade, & Bell, 1998; Ryan & Aikenhead, 1992) and pre-service teachers/teachers (Abd-El-Khalick & Lederman, 2000; Brickhouse, 1990; Craven, 2002; Tairab, 2001) do not have enough knowledge about NOS. Scientific knowledge is the descriptor of the situations in nature, and the changing structure of the continuous debate over what scientific knowledge is and how it is interpreted requires teachers to deal with this concept in a more critical way (Doğan et al., 2011). Training of the nature of scientific knowledge defined as the values and assumption in the nature of scientific knowledge (Lederman, 1992) has a crucial part in reaching the main targets (Abd-El-Khalick & Lederman, 2000). As the views of students on NOS are mostly shaped at school, teachers first need to comprehend science and nature of scientific knowledge well and develop various techniques with different practices and appropriate strategies in order to teach related notions (Tuan & Chin, 1999). With the aim of realizing this objective, pre-service teachers that are playing an active role in disseminating the scientific literacy need to be investigated on how and in what ways they gain the knowledge about this issue in their undergraduate programs and the problems confronted in practice procedure have to be examined. This is because it is assumed in the undergraduate curriculum that pre-service teachers graduate as people who have necessary knowledge and competences about NOS and internalize NOS. Consequently, NOS is supposed to be taught via various methods and techniques (Arık, 2010).

In the light of these explanations, we face the basic problem about "how to teach NOS". Pre-service teachers' learning this concept in the best way can be possible through divergent methods and techniques actualized within the scope of 'implicit approach' which is defined by many researchers in the literature in order to deal with this problem. As is known, implicit approach supports a process which can understand NOS by 'doing science' and can strengthen the notions related to NOS through scientific activities based on research-inquiry and scientific process skills (Abd-El-Khalick & Lederman, 2000; Barufaldi, Bethel, & Lamb, 1977). The argument underlying this approach is that no extra effort is needed for teaching NOS and just participating in the scientific research studies would suffice (McComas, 1996). Accordingly, it is claimed that project activities carried out within the implicit approach support students' learning of scientific knowledge and NOS.

PBL training in science education is of capital importance in terms of supporting the knowledge construction via research-inquiry method (Schneider, Krajcik, Marx, & Soloway, 2002). That is, students occupied with doing various research can deeply understand the content of science and the procedure, and hence they can reach the source of scientific knowledge at first hand (Bell, 2010; Brown & Campione, 1994). Active practices in the classes should aim at raising the interests of students towards NOS (Craven, 2002). PBL method is certain to feature the above properties. In this regard, project activities performed throughout the process in this study have become very effective on positively changing the pre-service teachers' (experimental group) views towards NOS. The existing literature indicates that teaching NOS through various methods and techniques can provide the students/pre-service teachers with a better viewpoint and they can transfer the acquired knowledge into the other related fields (Arık, 2010; Kubicek, 2005; Sert Çıbık, 2014). Directly relevant with this research, Morgil et al.'s (2009) study carried out with freshman students at a university attracts attention. In the aforementioned study, project-based laboratory experiments within the scope of scientific research were performed with students in addition to the experiments in basic chemistry laboratory course. Authors of that study concluded at the end of the research that knowledge levels of the students regarding NOS are increased. This finding shares similarities with those in the current study.

In recent years, many scientists, historians, philosophers and sociologists cannot reach a consensus on which themes need to be examined in the nature of scientific knowledge development. Along with the importance attached to students' pedagogical change and curriculum nowadays, most of the experts of the area accept the fact that raising students' awareness regarding NOS notions is associated with science curriculum, and some reforms need to be made in science teaching (McComas & Olson, 1998).This situation means that students' abilities and beliefs about doing science need to be improved in science classes (Ling et al., 2009). The nature of scientific knowledge includes a range of activities such as interpretation of the acquired knowledge by gathering the students through some scientific processes and disclosure of the results (Abd-El-Khalick et al., 1998). In terms of discussing the results of NOS, it is crucial to know the basic factors effective within the scope of nature of scientific knowledge and the level of the knowledge oriented to these factors during these activities. Although the aspects handled in this study have a mutually complementary feature, they have some divergent points. For instance, doing observations on any issues and doing inferences according to the findings is a scientific process. These kinds of scientific activities are different varieties of science and while clear ideas are raised about one of them, the other one may not develop an answer for this idea or it cannot be transferred into the other knowledge (Lederman, 1992). The first thing to do, hence, is to identify the ideas in the minds of teachers/pre-service teachers and to guide them in order to discriminate between these factors. This can be implemented by integrating the aspects involving the nature of science into the science curriculum at primary level and teacher training programs (McComas & Olson, 1998).

Similar to the results seen in Table 4, Liang et al. (2009) have also ended up with a similar finding and ascertained that pre-service teachers in three different countries (China, USA, Turkey) have unrealistic views on the aspects of the nature of scientific knowledge. In the same vein, Ayvacı and Er Nas (2010) have unfolded that pre-service teachers argued for a misconception "scientific knowledge can change but laws are more certain and thus they are not subject to change". The reasons underlying these misconceptions/imperfect knowledge of pre-service teachers who have a critical role in implementing the science curriculum (Liang et al., 2009) and how to set this knowledge right need to be challenged substantially. As a reason of this situation, one could put the finger on 'teaching curriculum' dominated by an approach narrowing science down to just *a set of scientific knowledge* since the early times of education. Indeed, the importance of the curriculum in teaching NOS is often emphasized in the studies of this field (Ayvacı & Er Nas, 2010; Köksal & Çakıroğlu, 2010; Liang et al., 2009; McComas & Olson, 1998; Yalvaç, Tekkaya, Çakıroğlu, & Kahyaoğlu, 2007). Moreover, in addition to the curriculum, its complementary features such as prior knowledge of students, teacher knowledge, textbooks and methods-techniques need to be examined in schools where knowledge and experiences about NOS are gained at first-hand. Even though it is not possible to evaluate these factors separately, the content of the textbooks and teacher factors have a priority.

Yalvaç et al. (2007) dealt with this issue in their study and claimed that the textbooks at primary school level include fallacious assumptions about NOS. For example, a general statement 'if an issue is taught through a scientific method, it can turn into a law via hypothesis, experiment and deduction' is involved in most of the textbooks. In the long run, this statement leads to a fallacy as 'laws are absolutely accurate knowledge' (Türkmen & Yalçın, 2001). As long as these fallacies are not replaced with the true knowledge in textbooks, this kind of misperceptions are certain to remain (Ayvacı & Er Nas, 2010). Instead of this, it would be much more beneficial to integrate the theory-laden aspect of NOS into the content by supporting with the concrete examples in nature and to teach it via various methods and techniques. Besides, addressing the history of science and its stages in the textbooks apart from including only topics and major scientific laws facilitates a better understanding of science, knowledge, science philosophy, history and nature of science (Türkmen & Yalçın, 2001). This is because instructional approaches clearly addressing NOS in acquiring more didactic results are more effective in supporting the development of NOS notions (Khishfe & Abd-El-Khalick, 2002). In-service and pre-service teachers bear tremendous responsibility regarding this issue.

In this study, we assume that the views of pre-service teachers towards the nature of scientific knowledge could be constructed around a more sophisticated and modern view via the project activities and a manner of approach in which the students stay in the background fails to satisfy this aim. When the results related to the validity of this hypothesis were analyzed, one observes that the experimental group has better reshaped their views towards the nature of scientific knowledge after PBHNOS teaching and they eliminated/corrected their existing misconceptions/imperfect knowledge. In addition, the experimental group stated their opinions as TV and IV for most of the aspects in the nature of scientific knowledge. However, as seen in Table 4, there were quite few opinions regarding NV and NC opinions were not formed by the participants. Based on these results, carrying out the courses of history of science, scientific knowledge, philosophical aspect of science and NOS through project activities in addition to theoretical explanations for a better understanding of the nature of scientific knowledge might be highly effective. Türkmen and Yalçın (2001) suggested that doing project activities by using simple materials in science classes actually introduces the students with the scientific method in an implicit way and students can also develop the understanding that science in the most general sense is figuring out the physical universe around us by means of these activities. Accordingly, simple science projects need to be prioritized beginning from the primary school, acquired data need to be tested via numbers and graphics and students need to be encouraged to interpret the findings in an accurate way. Another finding of this study can be interpreted as incorporating pre-service teachers in more science activities can facilitate dealing with NOS from various aspects and developing new understandings about this issue. According to these findings, project activities providing attainments at first-hand in acquiring more permanent and detailed knowledge about the nature of scientific knowledge became effective for changing the pre-service teachers' views.

RECOMMENDATIONS

Thanks to the findings of this study, some implications are presented for the researchers in this field:

1. Pre-service teachers need to gain experiences on the effective ways of teaching their knowledge of history and nature of science, which is acquired in undergraduate studies, to primary school students via in-class practices. With this aim, practical activities regarding NOS need to be carried out within/out of class time.
2. It is applicable to integrate applied courses, which will enable a more concrete understanding of science, science philosophy and scientific research, into the curriculum of science teaching departments along with the History and Nature of Science course prepared around a theoretical framework.
3. Direct-reflective, indirect and historical methods need to be introduced for teaching NOS and activities for its effective use need to be designed.

REFERENCES

Abd-El-Khalick, F., & Akerson. V. L. (2004). Learning about nature of science as conceptual change: Factors that mediate the development of pre-service elementary teachers' views of nature of science. *Science Education 88*(5), 785-810.

Abd-El-Khalick, F., & Lederman, N. G. (2000). Improving science teachers' conceptions of the nature of science: A critical review of the literature. *International Journal of Science Education 22*, 665-701.

Abd-El-Khalick, F., Bell, R. L., & Lederman, N. G. (1998). The nature of science and instructional practice: Making the unnatural natural. *Science Education 82*, 417-436.

Arık, S. (2010). *Geniş etkili güncel olayların öğretmen adaylarının bilimin doğası anlayışı üzerine etkisi* (Yayımlanmamış yüksek lisans tezi). Gazi Üniveristesi Eğitim Bilimleri Enstitüsü İlköğretim Anabilim Dalı Fen Bilgisi Öğretmenliği Bilim Dalı, Ankara.

Ayvacı, H. Ş., & Er Nas, S. (2010). Fen ve teknoloji öğretmenlerinin bilimsel bilginin epistemolojik yapısı hakkındaki temel bilgilerini belirlemeye yönelik bir çalışma. *Kastamonu Eğitim Dergisi 18*(3), 691-704.

Barufaldi, J. P., Bethel, L. J., & Lamb, W. G. (1977). The effect of a science methods course on the philosophical view of science among elementary education majors. *Journal of Research in Science Teaching 14*, 289-294.

Bell, R. L., Lederman, N. G., & Abd-El Khalick, F. (2000). Developing and acting upon one's conception of the nature of science: A follow-up study. *Journal of Research in Science Teaching 37*(6), 563-581.

Bell, S. (2010). Project-based learning for the 21st century: Skills for the future, the clearing house. *A Journal of Educational Strategies, Issues and Ideas*, *83*(2), 39-43.

Brickhouse, N. W. (1990). Teacher beliefs about the nature of science and their relationship to classroom practices. *Journal of Teacher Education 41*(3), 53-62.

Brown, A. L., & Campione, J. C. (1994). Guided discovery in a community of learners. In K. McGilly (Ed.), *Classroom lessons: Integrating cognitive theory and classroom practice* (pp. 229-270). Cambridge, MA: MIT Press/ Bradford Books.

Chen, S. (2006). View on science and education (VOSE) questionnaire. *Asia-Pacific Forum on Science Learning and Teaching 7*(2), Article 11.

Craven, J. A. (2002). Assessing explicit and tacit conceptions of the nature of science among preservice elementary teachers. *International Journal of Science Education 24*(8), 785-802.

Crowther, D. T., Lederman, N. G., & Lederman, J. S. (2005). Understanding the true meaning of nature of science. *Science and Children 43*(2), 50-52.

Çakıcı, Y. (2009). Fen eğitiminde bir ön koşul: Bilimin doğasını anlama. *M. Ü. Atatürk Eğitim Fakültesi Eğitim Bilimleri Dergisi 29*, 57-74.

Demirhan, C. (2002). *Program geliştirmede proje tabanlı öğrenme yaklaşımı* (Yayımlanmamış yüksek lisans tezi). Hacettepe Üniversitesi Sosyal Bilimler Enstitüsü, Ankara.

Doğan Bora, N., Arslan, O., & Çakıroğlu, J. (2006). Lise öğrencilerinin bilim ve bilim insanı hakkındaki görüşleri. *Hacettepe Eğitim Fakültesi Dergisi*, *31*, 32-44.

Doğan, N., Çakıroğlu, J., Bilican, K., & Çavuş, S. (2009). *Bilimin doğası ve öğretimi*. Ankara: Pegem Yayıncılık.

Doğan, N., Çakıroğlu, J., Çavuş, S., Bilican, K., & Arslan, O. (2011). Öğretmenlerin bilimin doğası hakkındaki görüşlerinin geliştirilmesi: Hizmet içi eğitim programının etkisi. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi 40*, 127-139.

Driver, R., Leach, J., Millar, R., & Scott, P. (1996). *Young people's images of science*. Buckingham, England: Open University Press.

Greaves-Fernandez, N. (2010). *Influence of views about the nature of science indecision-making about socio-scientific and pseudo-scientific issues* (Unpublished doctoral dissertation). The University of York, Department of Education, United Kingdom.

Gürses, A., Doğar, Ç., & Yalçın, M. (2005). Bilimin doğası ve yüksek öğrenim öğrencilerinin bilimin doğasına dair düşünceleri. *Milli Eğitim Dergisi 33*(166), 68- 76.

Hacıeminoğlu, E., Yılmaz-Tüzün, Ö., & Ertepınar, H. (2014). Development and validation of nature of science instrument for elementary school students. *Education 3-13 International Journal of Primary, Elementary and Early Years Education 43*, 258-283.

Hacıeminoğlu, E. (2013). Bilimin doğası ve öğretimi. M. Demirbaş (Ed.)., *Bilimin doğasına ilişkin öğrenme ürünlerinin değerlendirilmesi* (ss. 230-246). Ankara: Pegem Akademi Yayıncılık.

Kang, S., Scharmann, L. C., Noh, T., & Koh, H. (2005). The influence of students' cognitive and motivational variables in respect of cognitive conflict and conceptual change. *International Journal of Science Education 27*(9), 1037-1058.

Karasar, N. (2004). *Bilimsel araştırma yöntemi kavramlar-ilkeler-teknikler* (13. Baskı). Ankara: Nobel Yayın Dağıtım.

Kenny, D. A. (1975). A quasi-experimental approach to assessing treatment effects in the nonequivalent control group design. *Psychological Bulletin 82*(3), 345-362.

Khishfe, R., & Abd-El-Khalick, F. (2002). Influence of explicit reflective versus implicit inquiry-oriented instruction on sixth graders' views of nature of science. *Journal of Research in Science Teaching 39*(7), 551-578.

Kılıç, K., Sungur, S., Çakıroğlu, J., & Tekkaya, C. (2005). Ninth grade students' understanding of the nature of scientific knowledge. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi 28*, 127-133.

Köksal, M. S., & Çakıroğlu, J. (2010). Development of Nature of Science Scale (NSS) for advanced science students. *Journal of Baltic Science Education 9*, 87-98.

Kubicek, J. P. (2005). Inquiry-based learning, the nature of science, and computer technology: New possibilities in science education. *Canadian Journal of Learning and Technology 31*(1), 51.

Küçük, M. (2006). *Bilimin doğasının ilköğretim 7. sınıf öğrencilerine öğretmeye yönelik bir çalışma* (Yayımlanmamış doktora tezi). Karadeniz Teknik Üniversitesi, Fen Bilimleri Enstitüsü, Trabzon.

Lawson, A. E. (1982). The nature of advanced reasoning and science instruction. *Journal of Research in Science Teaching 19*, 743-760.

Lederman, N. G. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching 29*, 331-359.

Lederman, N. G. (2007). Nature of science: Past, present, and future. In S.K. Abell, & N. G. Lederman (Eds.), *Handbook of research in science education* (pp. 831-879). Mahwah, New Jersey: Lawrence Erlbaum Publishers.

Lederman, N. G., & Lederman, J. S. (2004). Project ICON: A professional development project to promote teachers' and students' knowledge of nature of science and scientific inquiry. In Buffler, A. & Laugksch, R (Eds.), *Proceedings of the 12th Annual Conference of the Southern African Association for Research in Mathematics, Science and Technology Education*. Durban: SAARMSTE.

Lederman, N. G., & Zeidler, D. L. (1987). Science teachers' conceptions of the nature of science: Do they really influence teacher behavior? *Science Education 71*(5), 721-734.

Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of nature of science questionnaire (VNOS): Toward valid and meaningful assessment of learners' conceptions of nature of science. *Journal of Research in Science Teaching 39*, 497-521.

Lederman, N. G., Lederman, J. S., & Antink, A. (2013). Nature of science and scientific inquiry as contexts for the learning of science and achievement of scientific literacy. *International Journal of Education in Mathematics, Science and Technology 1*(3), 138-147.

Lederman, N. G., Wade, P. D., & Bell, R. L. (1998). Assessing understanding of the nature of science: A historical perspective. In McComas, W (Ed.), *The nature of science in science education: Rationales and strategies* (pp. 331-350). The Netherlands: Kluwer Academic.

Liang L. L., Chen, S., Chen, X., Kaya, O. N., Adams, A. D., Macklin, M., & Ebenezer, J. (2009). Preservice teachers' views about nature of scientific knowledge development: An international collaborative study. *International Journal of Science and Mathematics Education 7*(5), 987-1012.

Liang, L. L., Chen, S., Chen, X., Kaya, O. N., Adams, A. D., Macklin, M., & Ebenezer, J. (2008). Assessing preservice elementary teachers' views on the nature of scientific knowledge: A dual-response instrument. *Asia-Pacific Forum on Science Learning and Teaching 9*(1), 1-20.

Liang, L. L., Chen, S., Chen, X., Kaya, O. N., Adams, A. D., Macklin, M., & Ebenezer, J. (2006, April). *Student understanding of science and scientific inquiry (SUSSI): Revision and further validation of an assessment instrument.* Paper Prepared for the 2006 Annual Conference of the National Association for Research in Science Teaching (NARST). San Francisco, CA.

McComas, W. F. (1993, April). *The effects of an intensive summer laboratory internship on secondary students' understanding of the NOS as measured by the test on understanding of science (TOUS)*. Paper Presented at the Annual Meeting of the National Association for Research in Science Teaching, Atlanta, GA.

McComas, W. F. (1996). Ten myths of science: Reexamining what we think we know about the nature of science. *School Science and Mathematics 96*(1), 10-16.
McComas, W., & Olson, J. (1998). The nature of science in international science education standards documents. In W.F. McComas (Ed.), *The nature of science in science education: Rationales and strategies* (pp. 41-52). Dordrecht: Kluwer Academic Publishers.
Morgil, İ., Temel, S., Güngör Seyhan H., & Ural Alşan E. (2009). Proje tabanlı laboratuar uygulamasının öğretmen adaylarının bilimin doğası konusundaki bilgilerine etkisi. *Türk Fen Eğitimi Dergisi (TÜFED) 6*(2), 92-109.
Moss, D. M. (2001). Examining student conceptions of the nature of science. *International Journal of Science Education 23*(8), 771-790.
Önen, F. (2013). Fen bilgisi öğretmen adaylarının aktivite temelli bilimin doğası öğretimine yönelik görüşleri ile bu öğretimin bilimsel tutum ve süreç becerilerine etkisi. *The Journal of Academic Social Science Studies 6*(7), 843-868.
Özgelen, S. (2010). *Exploring the development of pre-service science teachers' views on nature of science in inquiry-based laboratory instruction* (Unpublished doctoral dissertation). Department of Elementary Education, METU.
Roth, W., & Roychoudhury, A. (2003). Physics students' epistemologies and views about knowing and learning. *Journal of Research in Science Teaching 40*, 114-139.
Ryan, A. G., & Aikenhead, G. S. (1992). Students' preconceptions about the epistemology of science. *Science Education 76*, 559-580.
Ryder, J., Leach, J., & Driver, R. (1999). Undergraduate science students' images of science. *Journal of Research in Science Teaching 36*(2), 201-219.
Schneider, R., Krajcik, J., Marx, R. W., & Soloway, E. (2002). Student learning in project-based science classrooms. *Journal of Research in Science Teaching 39*(5), 410-422.
Schwartz, R. S., Akom, G., Skjold, B., Hong, H. H., Kagumba, R., & Huang, F. (2007, April). *A change in perspective: Science education graduate students' reflections on learning about NOS*. Paper Presented at the International Meeting of the National Association for Research in Science Teaching, New Orleans, LA.
Schwartz, R. S., Lederman, N. G., & Crawford, B. A. (2004). Developing views of nature of science in an authentic context: An explicit approach to bridging the gap between nature of science and scientific inquiry. *Science Education 88*(4), 610-645.
Sert Çıbık, A. (2014). *The effect of teaching project-based nature of science on teacher candidates' views about the NOS*. ISER 2014 World Conference, October 29-November 2, Cappadocia, Turkey.
Tairab, H. H. (2001). Pre-service teachers' views of the nature of science and technology before and after a science teaching methods course. *Research in Education 65*, 81-87.
Taşar, M. F. (2003). Teaching history and the nature of science in science teacher education programs. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi*, *13*(1), 30-42.
Taşar, M. F. (2006). Probing preservice teachers' understandings of scientific knowledge by using a vignette in conjunction with a paper and pencil test. *Eurasia Journal of Mathematics, Science and Technology Education 2*(1), 53-70.
Tuan, H. L., & Chin, C. C. (1999). *Promoting junior high school students' motivation toward physical science learning (I)*. Report No. NSC 88-2511- S018-013, Taiwan National Research Council.
Türkmen, L., & Yalçın, M. (2001). Bilimin doğası ve eğitimdeki önemi. *Afyon Kocatepe Üniversitesi Sosyal Bilimler Dergisi 3*(1), 189-195.
Yalvaç, B., Tekkaya, C., Çakıroğlu, J., & Kahyaoğlu, E. (2007). Turkish pre-service science teachers' views on science-technology-society issues. *International Journal of Science Education 29*(3), 331-348.
Zeidler, D. L., Walker, K. A., Ackett, W. A., & Simmons, M. L. (2002). Tangled up in views: Beliefs in the nature of science and responses to socioscientific dilemmas. *Science Education 86*, 343-367.

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APPENDIX.

Table 8. The syllabus content of the experimental group

Weeks	Topics/PBL steps	Activities carried out
1	Introduction to PBHNOS training	The definition and content of the course was presented. It was explained that the topics each week would be presented orally in order to fall in line with the syllabus of the course and then PBL process would start. Practice steps followed in PBL process were introduced to the pre-service teachers. 'Student Understanding of Science and Scientific Inquiry (SUSSI)' questionnaire was administered to the pre-service teachers as the pre-test.
2	What is knowledge, science, philosophy? The structure, function and types of science? PBL: Setting the targets	After the presentation of this week's topic to the pre-service teachers, each of them was asked to think of 2 *target sentences* about all the topics of the course. To do this, they were enabled to brainstorm on some issues which are considering all the developments in science from past to present, starting from the known aspects of scientists leading the science while creating their target sentences and problems confronted in daily life.
3	The stages of science history (first civilization, Ancient Greece, medieval and modern ages) PBL: Identifying and defining the work planned or the issue handled PBL: Determining the features of result report and its way of presentation	This week's topic was instructed to the pre-service teachers via concrete examples. Later, project topics were identified by choosing the best of the target sentences formed the previous week to guide them in achieving their goals. Relevance of project topics to the existing projects types in the literature was discussed and it was eventually decided to design projects as "research-discovery" projects by considering the content of the course. As an example to the research-discovery project, "Japan: It is investigated by taking some factors such as its culture, language, traditions in the past and today, way of dressing, food and houses into consideration" is shared with the pre-service teachers. They settled on how to write research reports contributing to research during the procedure and which points need to be paid attention. They also agreed on how to prepare weekly progress reports of the projects, how to do presentations and which basic points need to be included in the presentations.
4	Science reforms and their importance in science education PBL: Forming the groups PBL: Identifying the assessment criteria and levels of competence.	This week's topic was presented to the pre-service teachers through concrete examples. Later, as project method is based on group work, groups of 3-4 pre-service teachers were created according to their choices (12 different groups). Assessment criteria were identified for all the activities including the utility of the project and the process. Accordingly, the pre-service teachers were asked to fill in the forms of Weekly Group Project Assessment Report, Resources Used in Planning the Project and the Project Team and Division of Labor which were prepared by the researcher regarding the each week's activities about the projects of the pre-service teachers.
5	What is epistemology? Scientific knowledge and its features PBL: Creating a work schedule PBL: Identifying the control points PBL: Gathering information	This week's topic was presented to the pre-service teachers via concrete examples and in-class discussion. Project groups were asked to determine their study environment, to supply the equipment (if necessary), to create a detailed schedule on the phases of the project and to fall into line with this work schedule. For this reason, the researcher gave a "*work schedule*" to the groups to be filled weekly. The groups were told to be *under control* against the events and materials that can pose problems during the studies. In the following process, the groups were asked to identify the role of each member in the group by division of labor in terms of the finding research sources for the research process from beginning to the end. In this regard, they were advised to *gather information* from the sources such as journals, articles, newspapers, encyclopedias, textbooks and internet etc.
6	The nature of scientific notions (theory, phenomenon, laws, hypothesis) and their features PBL: Organizing and reporting the information	This week's topic was taught to the pre-service teachers through concrete examples and in-class discussions. All the information contributing the process of project development were analyzed and evaluated. The information evaluated in the development process was prepared for *reporting* by being noted down in phases.

Table 8. The syllabus content of the experimental group (Continued)

Weeks	Topics/PBL steps	Activities carried out
7	What is the nature of science? Its features	This week's topic was presented to the pre-service teachers through concrete examples and in-class discussions. After the topic presentation, the groups gave information about their project studies to the whole class.
8	In-class activities that can be used in teaching the nature of science	This week's topic was taught to the pre-service teachers via concrete examples and narrative activities. After the topic presentation, the groups gave information about their project studies to the whole class.
9	The approaches in teaching the nature of science	This week's topic was presented to the pre-service teachers via concrete examples and in-class discussions. After the topic presentation, the groups gave information about their project studies to the whole class.
10	The relation between technology and science (Scientific-Technologic knowledge).	This week's topic was presented to the pre-service teachers via concrete examples from daily life and in-class discussions. After the topic presentation, the groups have information about their project studies to the whole class.
11	Basic scientific process skills and their relations to the nature of science	This week's topic was presented to the pre-service teachers through concrete examples and in-class discussions. After the topic presentation, the groups gave information about their project studies to the whole class.
12	Activities uncovering the features of scientific knowledge (an activity for each feature)	This week's topic was taught to the pre-service teachers through concrete examples and in-class discussions. For instance, scientific knowledge requires evidence obtained from experiments and observations. Activity: What is in the tube? After the topic presentation, the groups gave information about their project studies to the whole class.
13	Nature of science activities (3 practical examples)	This week's topic was taught to the pre-service teachers through concrete examples and in-class discussions. A sample activity: Does life exist on Mars? 'Student Understanding of Science and Scientific Inquiry (SUSSI)' questionnaire was administered to the pre-service teachers as the post-test.
14	PBL: Project presentations	The projects prepared as reports were presented to the class via oral presentation, posters and slide shows and related feedbacks were given to the groups (*presentation of projects*)