

# Comparing Effects of Two Different Explicit–Reflective Instructions on Pre-School Prospective Teachers’ View about Nature of Science and Scientific Knowledge

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**ABSTRACT** This study aims to compare the effect of formative assessment with explicit-reflective instruction and explicit-reflective on pre-school prospective teachers' views about the nature of science and scientific knowledge. In this study, it was used a pretest-posttest nonequivalent control group design and the sample of the study consists of 66 pre-school prospective teachers in the 2<sup>nd</sup> grade. There are 33 of them were assigned control group and the others were assigned as the experimental group. Since the students could not be randomly grouped in the study, a quasi-experimental design was used. In this study, the nature of science scale (NOSS) and the attitude scale towards scientific knowledge (SKS) were used as pre-test, post-test and retention test. In order to teach the students by using nature of science (NOS) and scientific knowledge (SK), open-reflective instruction was used in the control group, and open-reflective instruction and embedded formative assessment were applied in the experimental group. NOSS and SKS were used as a pre-test, post-test and retention-test in this study. In order to teach the students NOS and SK, while Explicit-reflective instruction was applied in the control group, formative assessment embedded with Explicit-reflective instruction was applied experimental group. As a result of the study, it was determined that the formative assessment embedded with Explicit-reflective instruction was more positively and permanently changed on pre-school prospective teachers' view about NOS and SK than the other method.

**Keywords** Explicit-reflective instruction, Formative assessment, Nature of Science, Scientific Knowledge, Pre-school prospective teacher

## 1. INTRODUCTION

It is emphasized that every citizen should receive a good education in order for countries to create a strong future, especially to be educated as science and technology literate (Eş & Sarıkaya, 2010; Güneş & Kardeş, 2016). In recent years, necessary reforms have been made in science education. While developing these reforms, it was taken into account that students must be science literate to adapt to changing life (NRC, 1996; NSTA, 2000).

While there is a consensus in many areas about the importance of science literacy, scientific literacy has been attributed to different meanings by many researchers (DeBoer, 2000). As a result, various definitions of scientific literacy have been made (NRC, 1996). The most widely used of these definitions is that scientific literacy is the ability to access and use information (AAAS, 1993). Therefore, individuals who are having scientific literate are expected to have skills such as proposing concrete and rational solutions to problems and using scientific methods

and techniques when they encounter problems in daily life (Altındağ, 2010). In addition, scientifically literate individuals, it is stated that he can easily understand the scientific knowledge (SK), the nature of science (NOS), the interrelationship between science and society, and between science and humanities (Roberts, 2007).

Researchers agree on a subject that emphasizes students' understanding of the NOS, which is an epistemological aspect of scientific literacy (Bybee, 1997). The National Science Educational Standards (NRC, 1996) emphasized that the NOS concept is a component of scientific literacy, has become one of the priorities aims of teachers in science teaching. Therefore, it is not enough to teach science concepts alone to gain students' scientific literacy. The Nature of Science, seen as a sub-dimension of

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scientific literacy in science education, It is researched by science educators, science historians, sociologists, and philosophers in the last thirty years. There is no consensus about the definition of the NOS among science historians and philosophers. However, it seems that students from pre-school to university (K-12) agree on what they should gain about the nature of science (Abd-El-Khalick, Bell, & Lederman, 1998).

There is some basic agreement about the aspects of NOS and features of SK among science educators. The first aspect of NOS is "tentative nature", which expresses that principles, laws, and theories can change in line with new evidence, change in thinking, and developments in the cultural and social environment (McComas, Clough, & Almazroa, 1998). The "empirical nature" aspect means that scientific knowledge arises from observations of the natural world. Scientists need experimental evidence to produce SK. Therefore, the availability of new evidence requires a review of scientific knowledge (McComas, 1998). The other aspect, "observation and inference," have different meanings; while observations are descriptive facts about natural phenomena that we create through our senses, inferences are interpretations of those observations. This point of view explains the differences between these two concepts (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). For another aspect, "creative and imaginative nature", refers to the importance of imagination and creativity in producing scientific knowledge (McComas, 1998).

The aspect of "social and cultural embeddedness" dictated that scientific knowledge revealed by scientists is influenced by the culture and society of the scientist (McComas et al., 1998). The aspect of "scientific theories and laws"; are different forms of scientific knowledge. According to this perspective, it is emphasized that there is no hierarchical relationship between laws and theories. Scientific laws explain the relationships between visible phenomena, while scientific theories are well-organized and highly proven explanations. It is also emphasized that although scientific laws can be tested, scientific theories cannot be directly tested because they are based on certain assumptions and unobservable entities. The aspect "theory-laden nature of science" explains that scientists depending on a particular theory, his work shows that they accept some assumptions and principles. In his work, they sometimes believe that while evaluating their observations in the light of the theories they adhere to, theories constitute their expectations (McComas, 1998). McComas (1998) argued that expectations affect observations and conclusions. He stated that they are not impartial.

In the researches, it is stated that the understanding of the nature of science that teachers have and their teaching of the nature of science have critical importance in terms of science education and teaching (Deniz & Adibelli, 2015; Hanuscin, Lee, & Akerson, 2011; Mıhladıız & Doğan, 2017;

Prima, Utari, Chandra, Hasanah, & Rusdiana, 2018). Teaching the NOS and aspects to students has long been a goal of science educators (Kang, Scharmann, & Noh, 2005). However, students and teachers generally lack sufficient understanding of NOS (Pomeroy, 1993; Ryan & Aikenhead, 1992). It is thought that although pre-service teachers have taken the nature of science and history of science courses, they are still insufficient in establishing the relationship between theory and law (Önen Öztürk, 2019). For many years, scientists and science educators have agreed on the aim of helping students improve informed NOS (Abd-El-Khalick et al., 1998). Therefore, any reforms should be made in the curriculum and the pedagogical field to improve students' understanding of the NOS in science education (AAAS, 1993; NRC, 1996; NSTA, 2000). However, the researchers state that students, teacher candidates, and teachers from kindergarten to 12<sup>th</sup> grade (K-12) did not reach the desired understanding about NOS (Abd-El-Khalick & Lederman, 2000; Önen Öztürk, 2019). Therefore, it is seen that it is crucial to increase the number of studies aimed at gaining the perspective of the NOS at all grades starting from the pre-school period to 12<sup>th</sup> grade (K-12).

When pre-school age is considered the period when the NOS is founded, pre-school teachers have significant responsibilities in having students acquire the elements of the NOS, adapting the targeted dimensions into the instructional process, and implementing ways of them. Moreover, in pre-school, children conduct preliminary scientific experiments, observe the experimental process, interpret the events, and use their imagination and creativity. Therefore, the quality of teachers and the activities are essential for these children's quality of instruction. Therefore, it is crucial to teach NOS and its components to pre-school teachers and prospective teachers in this sense. In the literature, there are some approaches for teaching NOS.

### 1.1. Teaching Approaches Nature of Science

Three approaches, such as historical, implicit, and explicit-reflective, were used to teach NOS for students, pre-service, and in-service teachers (Lederman, 1992). In the historical approach, to students understand the NOS, it is discussed how and under what conditions scientists worked in history. In addition, a historical approach can be used to show the change of SK in the historical process and to understand the NOS by using the history of science (Khishfe & Abd-El-Khalick, 2002). The implicit approach argues that the NOS does not require much effort to teach teachers or students. Instead, they can learn NOS spontaneously by including them in scientific activities (Abd-El-Khalick & Lederman, 2000). Finally, the Explicit-Reflective approach considers that a direct effort is required to teach NOS contrary to the implicit approach. According to this approach, while teaching the NOS, activities involving scientific research skills, scientific

discussions, and models are carried out with teachers or students. Then, the students or teachers tried to comprehend the NOS by giving feedback on the activities (Gess-Newsome, 2002).

In many recent studies, it is emphasized that the explicit-reflective teaching approach has positively changed the teachers' thoughts about the concept of NOS, and This approach is more effective than other approaches (Akerson & Abd-El-Khalick, 2005; Akerson & Hanuscin, 2007; Akerson & Volrich, 2006; Bell, Lederman, & Abd-El-Khalick, 2000; Moss, Abrams, & Robb, 2001).

In order to improve the effectiveness of the explicit-reflective approach, assessment procedures can also be used in teaching NOS and SK. For example, an assessment may be diagnostic, summative, and formative, but formative assessment is used during the instructional process.

### 1.2. Formative Assessment

The formative assessment, which came to the forefront with the book *Working Inside the Black Box* by Black & William (1998a), is expressed as an assessment for learning without any giving marks to students (Black & William, 2004; Black & William, 2009; Keeley, Eberle, & Farrin, 2005). Black & William (1998a), Black & William (1998b), and Bryant & Timmins (2002) define formative assessment as a cycle in which the assessment data is used for improving learning and assessment is carried out again. The fundamental aim of this assessment is to have the students develop desired behaviors and guide students (Black & William, 1998b; Bell & Cowie, 2001; Gipps, 1994; Metin, 2014). For this aim, teachers give feedback to students about the deficient and insufficient points of the activities they conduct (Black & William, 1998a; Bell & Cowie, 2001). While students understand their deficient and insufficient aspects and direct their studies with the feedback, teachers decide how to continue instruction according to students' learning conditions (Bell & Cowie, 2001; Brookhart, 2001). This formative assessment helps teachers have information about their students' learning, decide the following instruction step, and help students learn more effectively (Clarke, 2001). The most critical matter that should be considered is that formative assessment should be integrated into instruction and continuous (Torrance & Pryor, 1998).

A common conclusion in the literature is that the assessment type directs the learning (Biggs & Watkins, 1996). They effectively increase the level and quality of learning when used properly (Black & William, 2002; Clarke, 2001). Many researchers state that formative assessment increases the quality and level of students' learning (Ali & Iqbal, 2013; Black & William, 1998a; 1998b; Black, Harrison, Lee, Marshall, & William, 2002; Clarke, 2001; Crooks, 1988; Gallagher, 2000; Harlen, Brand, & Brown, 2003; Stiggins & Conklin, 1992; Torrance & Pryor, 1998). An effective formative assessment involves; sharing

the learning aim with students, giving feedback to students to correct their mistakes and complete their deficiencies, helping students investigating their own progress to find the deficiencies, and increasing the motivation and self-confidence, which are rather important for effective learning and development, by using proper assessment techniques (ALARG, 2002). Therefore, it is possible to say that these activities can be used as a method in the context of formative assessment. Thus, Black and William (1998a), Black and William (2002), Brookhart (2001), Clarke (2001) and Harlen and James (1997) found that formative assessment; increase the learning quality and level of students, help them learn effectively, increase their motivation and have students learn self-assessment. Besides, Harlen et al. (2003) state that formative assessment is highly effective in realizing students' research-based learning. Llewellyn (2002) and Bonner (2005) express that research-based learning teaches students scientific research, studies, and how to think like a scientist.

It is essential that teachers who work in pre-school have enough information about NOS and correctly explain NOS to students in order for early childhood students to comprehend the nature of science fully. For prospective teachers who will teach in pre-school after graduation to comprehend NOS correctly, it is necessary to provide practical training to explain NOS. Therefore, it is essential to conduct activities that clearly emphasize the nature of science lessons to pre-service teachers and provide them with feedback on applications to learn better. It is thought to become more effective by using formative assessment related to NOS and SK teaching activities in the teaching process.

In this context, this study aims to compare the effect of formative assessment with explicit-reflective instruction and explicit-reflective on pre-school prospective teachers' views about NOS and SK. This study is thought to be significant for integrating formative assessment with explicit-reflective instruction of NOS. Furthermore, this aspect presents an example for researchers who conduct research on NOS and teacher educators who train pre-school and science teachers.

## 2. METHOD

As the prospective pre-school teachers could not be grouped randomly within the research, it was decided to use a quasi-experimental design. The quasi-experimental design has been used in this study because it allows randomly deciding whether one or more of the pre-formed groups are experimental and one or more of the control groups when random grouping is not possible (Creswell, 2005; Judd, Smith, & Kidder, 1991). This study used a pre-test-posttest nonequivalent control group design (Fraenkel & Wallen, 2006). This design has an experimental and a control group, and the groups are determined randomly. In the design, a pre-test is implemented for both groups,

experimental intervention is carried out with an experimental group, no specific intervention is done for the control group, and a post-test is applied for both groups again (Creswell, 2005; Fraenkel & Wallen, 2006). In this study, one group of prospective pre-school teachers in 2<sup>nd</sup> grade was assigned randomly as an experimental group and the other as a control group.

### 2.1. Research Sample

The study sample consists of 66 prospective pre-school teachers in the 2<sup>nd</sup> grade. Fifty-six of the pre-service teachers are female, and ten are male, and their average age is between 21 and 25 years old. Thirty-three pre-school prospective teachers were assigned the control group among these students as the experimental group found by the other pre-school prospective teacher. Pre-school prospective teachers in both groups come from similar educational and socio-economic backgrounds. The researcher applied an application related to the nature of science in experimental and control groups. The researcher had 11 years experience in teaching science, a doctorate in science education, and carried out some research regarding the nature of science and science process skills.

### 2.2. Study Context

The study was carried out in Science Education Course in the fifth semester of the Pre-school Education program. The course is instructed four hours a week, two theoretical and two practices, and the term has 14 weeks. The course covers; the subjects like the importance of science and nature, the instruction of basic science concepts and scientific thinking skills in the pre-school period, preparation of activities and materials for NOS and scientific process skills, and the implementation of these materials. The seven essential components handled in science education course about NOS and scientific process skills are as follows; scientific knowledge is; i) tentative, ii) experimental, iii) subjective, iv) a result of imagination and creativity, v) affected by social and cultural structure, vi) related with observation and implication, vii) related with law and theory. In this study, prospective pre-school teachers were informed about these seven components,

and implementations were carried out. Then, prospective pre-school teachers designed activities for pre-school children in order to have them gain these essential components.

### 2.3. Data Collection Tool

“Nature of science scale (NOSS)”, which was developed by Özgelen (2013), and “attitude scale towards scientific knowledge (SKS)”, developed by Ayvaci (2007), were used in this study.

#### Nature of Science Scale

The NOSS consisted of 30 items developed by Özgelen (2013), and it was applied to 655 pre-service teachers in four different universities. Exploratory factor analysis was made by using the SPSS program, the scale was found to have five factors, and the total number of items was found to be 19. The reliability of the scale as a result of all was .83. Furthermore, a sample of 391 pre-service teachers, confirmatory factor analysis was conducted with the AMOS program. According to the confirmatory factor analysis results,  $\chi^2/df$  rate was 0.83. This ratio (0.83) shows that the measurement model fits the data well. Some examples of the scale items are given in Table 1.

#### Scientific Knowledge Scale

This scale is designed to evaluate the students' thoughts about scientific knowledge quantitatively. The scale contains 25 items about SK, which are in five-point Likert type. Each item of the scale was developed by taking the components of science and nature of SKS and the characteristics in the literature. After the analysis by a language expert, the scale was applied. Then, the data were analyzed by the SPSS program, and factor load value (.515–.885) and total variance percent (42%) were calculated for each item. The internal consistency of the scale was found to be 0.73. Some examples of the items in the scale are given in Table 2.

### 2.4. Instructional Materials

Four activities such as *i) the investigation of the cubes, ii) old teacher, iii) young or old?, iv) sheet roll* performed in the class to

**Table 1** Examples of the Nature of Science scale items

Item		Characteristics of Scientific Knowledge
5	Scientific knowledge changes in time.	Tentative
7	Scientific knowledge is created only as a result of experiments and objective observations.	Empirical
9	The studies of scientists are influenced by their thought about the same subject.	Subjective
10	Scientists use imagination while creating scientific knowledge.	Creative
13	Scientific questions and methods change according to historic conditions.	Social-cultural
18	The two scientists observing the same room may have different inferences.	Relationship between observations and inferences
25	Scientific theories turn into laws in time.	Relationship between theory and law

**Table 2** Examples of the Scientific Knowledge scale items

Item	
2	Science may testify something, solve a problem or find the answer to a question.
4	Most scientists work on their own.
10	Scientists have solved most of the great mysteries of nature.
15	Science may research things and events even millions of years.
18	The scientist's race, gender, nationality, and religion may influence their work.
20	Scientist mostly tries to disprove their thoughts.
25	The conflict between scientists is one of the weaknesses of science.

have prospective pre-school teachers in experimental and control groups comprehend the NOS.

*i) The cubes investigation:* In this activity, prospective pre-school teachers were given a cube with names and numbers on their sides. They were asked to discover the relations between the names and numbers and explain them by presenting pieces of evidence. The question examined in this activity was, "What is there on the bottom of the cube?" The activity lasted nearly 90 minutes, and pre-service teachers tried to comprehend the experimental, tentative, imaginative, and creative nature of science and the difference between observation and inference.

*ii) Old teacher:* This activity focuses on the fact that "The knowledge and expectation that scientist have while working may influence the way of inferencing it." The activity lasted 45 minutes, and some pictures were shown to students which were said to belong to a teacher who started teaching recently. By examining these pictures, prospective pre-school teachers were asked to recognize the changes on the teacher's face. At the end of the activity, prospective pre-school teachers were told that the picture belonged to a woman, and they were asked why they saw the teacher, not the woman. This activity aims to have pre-service teachers learn the difference between observation and inference and gain the theoretical and socio-cultural nature of science.

*iii) Old or young?:* This activity focuses on the fact that scientists can see different things while looking at the same data or events. The activity took 45 minutes. First, pictures that show differences in different perspectives were shown to students, and they were asked to say the thing they saw. The discussions on the pictures stressed that two individuals looking at the same thing might see different things. This activity aims to have prospective pre-school teachers learn the difference between observation and inference and gain the subjective, theoretical and socio-cultural nature of science.

*iv) Sheet roll:* This activity presents an experiment to students with a system prepared by using sheet rolls and

how it works. Then, prospective pre-school teachers were asked to think about the internal structure of the roll by working together and setting up a system similar to the activity by using the rolls given to them. Next, the prospective pre-school teachers worked in groups, generated hypotheses about the internal structure of the roll by discussing their ideas, and designed models based on this hypothesis. After that, each team explains the model by presenting how it works. This activity aims to have pre-service teachers learn the difference between observation and inference and gain the tentative, experimental, imaginative, and creative nature of science.

The researcher performed these activities with experimental and control groups in two weeks and 8 hours. In addition, the researcher had the role of facilitator during the activities and encouraged prospective pre-school teachers to discuss activities.

### 2.5. Implementation Process

Within the research context, an explicit-reflective teaching approach was applied to teach the control group the nature of science and the properties of scientific knowledge. The activities of "The investigation of the cubes", "Old teacher", "Old or young?", "Sheet roll" were carried out by the academician at eight weeks following direct reflective teaching.

The experimental group was explained all of the activities in the control group using the direct reflective learning method. In addition, the experimental group was asked to prepare activities to teach the nature of science at the end of each activity. Pre-school prospective teachers were asked to present their activities in the classroom environment. During the presentation, the academician provided feedback on whether the activities reflected the nature of science. Pre-school prospective teacher rearranged their activities according to this feedback.

The activities of the experimental and control groups during 15 weeks are given in Table 3.

### 2.6. Data Analysis

The data obtained using achievement tests as the pre-test, post-test, and retention tests have been analyzed using the SPSS program. Because the groups have been randomly assigned before the implementation and the data collection tool is an interval scale, a t-test has been used in data analysis. In addition, the Kolmogorov-Simonov test was applied to determine whether the data had a normal distribution, and results showed that they presented a normal distribution ( $p > 0.05$ ). Levene test was used for testing the homogeneity of variances of experimental and control groups. Because the result of the Levene test was higher than 0.05, it was specified that both groups were equal. Independent samples t-test was used to compare the experimental and control group's pre-test, post-test, and retention test results. Paired samples t-test was used to analyze the pre-test, post-test, and post-test retention test average point differences of each group's test results. The

**Table 3** Implementation process of learning activities

Weeks	Activities in Experimental Group	Activities in Control Group
Week 1	NOSS and SKS were implemented as a pre-test in the first course. The implementation of each scale took 20 minutes.	NOSS and SKS were implemented as a pre-test in the first course. The implementation of each scale took 20 minutes.
Week 2	Pre-school prospective teachers were informed about science and scientific knowledge and what type of characteristics science-literate people have. Besides, they were informed about what NOS means and characteristics of SK such as tentative, experimental, subjective, experimental, imaginative, creative, socio-cultural, and its relation with observation and inference, and law and theory.	Pre-school prospective teachers were informed about science and scientific knowledge and what type of characteristics science-literate people have. Besides, brief information was given to them about NOS and the characteristics of SK.
Week 3	The cubes activity analysis was performed to have prospective pre-school teachers comprehend the tentative, experimental, imaginative, and creative NOS and the difference between observation and inference. The group members also had discussions during the activity. Besides, prospective teachers were asked to determine a science subject at the pre-school level and perform an activity to have prospective pre-school teachers comprehend the tentative, experimental, imaginative, and creative NOS and the difference between observation and inference.	Pre-school prospective teachers were informed about science's tentative, experimental, imaginative, and creative nature.
Week 4	The activities that prospective pre-school teachers designed were discussed in the class, and feedback was given to them about how to correct deficiencies and mistakes and make the activity better. In this process, the prospective pre-school teachers' activities were evaluated using formative assessment.	Pre-school prospective teachers were informed about the socio-cultural influences on scientific knowledge, its relations with observation and inference, theory, and law.
Week 5	Old teacher activity was performed to have prospective pre-school teachers comprehend the theoretical and socio-cultural NOS and the difference between observation and inference. The prospective pre-school teacher also had discussions on activities. Besides, they were asked to design an activity for these characteristics of science.	The cubes activity analysis was performed to have prospective pre-school teachers comprehend the tentative, experimental, imaginative, and creative nature of science and the difference between observation and inference. The group members also had discussions during the activity.
Week 6	The activities that prospective pre-school teachers designed were discussed in the class, and feedback was given to them about how to correct deficiencies and mistakes and make the activity better.	Old teacher activity was performed to have prospective pre-school teachers comprehend science's theoretical and socio-cultural nature and the difference between observation and inference. The students also had discussions on activities.
Week 7	"Old or young?" activity was performed to have prospective pre-school teachers comprehend the subjective, theoretical and socio-cultural nature of science and the difference between observation and inference. The prospective pre-school teachers also had discussions on activities. Besides, they were asked to design an activity for these characteristics of science.	"Old or young?" activity was performed to have prospective pre-school teachers comprehend the subjective, theoretical and socio-cultural nature of science and the difference between observation and inference. The prospective pre-school teachers also had discussions on activities.
Week 8	The pre-school prospective teacher-designed activities were discussed in the class, and feedback was given to them about how to correct deficiencies and mistakes and make the activity better.	"Sheet roll" activity was performed to have prospective pre-school teachers comprehend the tentative, experimental, imaginative, and creative nature of science and the difference between observation and inference. The prospective pre-school teachers also had discussions on activities.
Week 9	"Sheet roll" activity was performed to have prospective pre-school teachers comprehend the tentative, experimental, imaginative, and creative NOS and the difference between observation and inference. The prospective pre-school teachers also had discussions on activities. Besides, they were asked to design an activity for these characteristics of science.	Pre-school prospective teachers continued sheet roll activity.
Week 10	The activities that prospective pre-school teachers designed were discussed in the class, and feedback was given to them about how to correct deficiencies and mistakes and make the activity better.	The NOSS and SKS were implemented as post-test.
Week 11	The NOSS and SKS were implemented as post-test.	
Week 15	The NOSS and SKS were implemented as retention tests.	The NOSS and SKS were implemented as retention tests.

level of significance was considered as  $p = .05$ . In order to comment on a test result, considering only the significance level is not sufficient (Yıldırım & Yıldırım, 2011). The result may be meaningful, but its effect may be low. Effect size is calculated in different ways in different tests (Meline & Wang, 2004), and Cohen's  $d$  was calculated in this study.

Effect size is considered as; low between 0–0.2, moderate around 0.5, and high 0.8 and above (Cohen, 1988). The data obtained in this study have been interpreted by considering correlation, mean, standard deviation,  $p$ -value, and Cohen's  $d$ .

### 3. FINDINGS

The findings of the study were analyzed in five steps. In the first one, the results of independent samples t-test applied to means of pre-tests of experimental and control groups have been given in Table 4.

Table 4 shows that there is not a difference between the pre-test variances of experimental and control groups. While pre-test mean of experimental group is higher than the control group's ( $\bar{x}_{\text{Experimental}} = 87.09$ ;  $\bar{x}_{\text{Control}} = 86.53$ ;) in NOSS, there is not statistically a significant difference between pre-test means of experimental and control groups ( $t = .446$ ;  $p > 0.05$ ). Besides, the pre-test mean of the experimental group is higher than the control group's ( $\bar{x}_{\text{Experimental}} = 99.09$ ;  $\bar{x}_{\text{Control}} = 97.97$ ) in SKS. However, this difference is not significant in statistical terms ( $t = .931$ ;  $p > 0.05$ ).

The independent samples t-test applied to means of post-tests of experimental and control groups have been given in Table 5.

Table 5 shows that there is not a difference between the post-test variances of experimental and control groups. However, the means of pre-service teachers in the experimental group in NOSS is higher than the control group's ( $\bar{x}_{\text{Experimental}} = 101.68$ ;  $\bar{x}_{\text{Control}} = 92.47$ ). The results of the t-test show that there is a significant difference ( $t =$

$6.964$ ;  $p < 0.05$ ) in favor of the experimental group. Also, the means of pre-service teachers in the experimental group in SKS is higher than the control group's ( $\bar{x}_{\text{Experimental}} = 108.15$ ;  $\bar{x}_{\text{Control}} = 100.71$ ). The results of the t-test show that there is a significant difference ( $t = 5.620$ ;  $p < 0.05$ ) in favor of the experimental group.

The independent samples t-test applied to means of retention tests of experimental and control groups have been given in Table 6.

Table 6 shows that there is not a difference between the post-test variances of experimental and control groups. However, the means of pre-service teachers in the experimental group in NOSS as a retention test is higher than the control group's ( $\bar{x}_{\text{Experimental}} = 100.47$ ;  $\bar{x}_{\text{Retention}} = 90.59$ ). The results of the t-test show that there is a significant difference ( $t = 17.286$ ;  $p < 0.05$ ) in favor of the experimental group. Also, the means of pre-service teachers in the experimental group in SKS as a retention test is higher than the control group's ( $\bar{x}_{\text{Experimental}} = 106.50$ ;  $\bar{x}_{\text{Retention}} = 99.15$ ). The results of the t-test show that there is a significant difference ( $t = 8.883$ ;  $p < 0.05$ ) in favor of the experimental group.

The results of paired samples t-test applied to means of pre-tests and post-tests of experimental and control groups have been given in Table 7.

**Table 4** Independent samples t-test results of experimental and control group's pre-test

Pre-test Results	Experimental Group		Control Group		t	p
	$\bar{x}$	SD	$\bar{x}$	SD		
NOSS	87.09	5.817	86.53	4.433	.446	.657
SKS	99.09	5.749	97.97	3.989	.931	.355

**Table 5** Independent samples t-test results of experimental and control group's post-test

Post-test Results	Experimental Group		Control Group		t	p
	$\bar{x}$	SD	$\bar{x}$	SD		
NOSS	101.68	4.013	92.47	6.964	6.678	.00
SKS	108.15	5.930	100.71	4.945	5.620	.00

**Table 6** Independent samples t-test results of experimental and control group's post-test

Retention Test Results	Experimental Group		Control Group		t	p
	$\bar{x}$	SD	$\bar{x}$	SD		
NOSS	100.47	2.957	90.59	1.540	17.286	.00
SKS	106.50	4.406	99.15	1.971	8.883	.00

**Table 7** Paired samples t-test results of experimental and control group's pre-test and post-test

Groups	Tests	NOSS				SKS					
		$\bar{x}$	SD	t	p	r	$\bar{x}$	SD	t	p	r
Experimental Group	Pre-test	87.09	5.817				99.09	5.749			
	Post-test	101.68	4.013	12.036	.00	.83	108.15	5.930	6.396	.00	.61
Control Group	Pre-test	86.53	4.433				98.56	3.791			
	Post-test	92.47	6.964	4.196	.00	.41	100.71	4.945	2.009	.004	.24

**Table 8** Paired samples t-test results of experimental and control group's post-test and retention test

Groups	Tests	NOSS		t	p	SKS		t	p
		$\bar{x}$	SD			$\bar{x}$	SD		
<b>Experimental Group</b>	Post-test	101.68	4.103	1.411	.163	108.15	5.930	1.30	.133
	Retention	100.47	2.957			106.50	4.406		
<b>Control Group</b>	Post-test	92.47	6.964	1.539	.240	100.71	4.945	1.707	.095
	Retention	90.59	1.540			99.15	1.971		

Table 7 shows that post-test means of experimental group in NOSS and SKS ( $\bar{x}_{NOSS} = 101.68$ ;  $\bar{x}_{SKS} = 108.15$ ) are higher than its pre-test means ( $\bar{x}_{NOSS} = 87.09$ ;  $\bar{x}_{SKS} = 99.09$ ). It has been found that experimental group has a significant increase in post-test results ( $t_{NOSS} = 12.036$ ;  $p < 0.05$ ;  $t_{SKS} = 6.396$ ;  $p < 0.05$ ) and the effect sizes ( $r_{NOSS} = .83$ ;  $r_{SKS} = .61$ ) of this increase are in high level. The table also shows post-test means of control group ( $\bar{x}_{NOSS} = 92.47$ ;  $\bar{x}_{SKS} = 100.71$ ) are higher than its pre-test means ( $\bar{x}_{NOSS} = 86.53$ ;  $\bar{x}_{SKS} = 98.56$ ). It has been found that control group has a significant increase in post-test results ( $t_{NOSS} = 4.196$ ;  $p < 0.05$ ;  $t_{SKS} = 2.009$ ;  $p < 0.05$ ) and the effect sizes ( $r_{NOSS} = .41$ ;  $r_{SKS} = .24$ ) of this increase are in high level.

The research results show a statistically significant difference between both groups' pre-test and post-test results. However, it was determined that the effect size of the experimental group was more significant than the control group in the NOSS and SKS tests.

The results of paired samples t-test applied to means of post-tests and retention tests of experimental and control groups have been given in Table 8.

Table 8 shows that post-test means of experimental group in NOSS and ASTSK ( $\bar{x}_{NOSS} = 101.68$ ;  $\bar{x}_{SKS} = 108.15$ ) are higher than its retention test means ( $\bar{x}_{NOSS} = 100.47$ ;  $\bar{x}_{SKS} = 106.50$ ). However, a significant difference has not been found ( $t_{NOSS} = 1.411$ ;  $p > 0.05$ ;  $t_{SKS} = 1.300$ ;  $p > 0.05$ ) between post-tests and retention tests. The table also shows post-test means of control group ( $\bar{x}_{NOSS} = 92.47$ ;  $\bar{x}_{SKS} = 100.71$ ) are higher than its retention test means ( $\bar{x}_{NOSS} = 90.59$ ;  $\bar{x}_{SKS} = 99.15$ ). However, these differences are not significant ( $t_{NOSS} = .1539$ ;  $p > 0.05$ ;  $t_{SKS} = 1.707$ ;  $p > 0.05$ ) in statistical terms.

#### 4. RESULTS AND DISCUSSION

An extensive literature review shows that perceptions about NOS and SK substantially affect science learning in students and teachers (Abd-El-Khalick & Lederman, 2000; Akerson & Abd-El-Khalick, 2005; Altındağ, 2010; Khishfe & Abd-El-Khalick, 2002; Lederman, 1992; Moss et al., 2001).

This study aims to compare the effect of formative assessment embedded with explicit-reflective instruction and explicit-reflective on pre-school prospective teachers' views about the nature of science and scientific knowledge.

When the results were obtained from the NOSS and SKS, which were applied as a pre-test to prospective pre-school teachers in the experimental and control groups, it was observed that there was a homogeneous distribution. Furthermore, the pre-test found no statistically significant difference between the experimental and control groups in both scales. This means both groups had similar features before the implementation process. Equivalence of the sample group is essential for the correct interpretation of the data obtained during the experimental research process (Creswell, 2005; Fraenkel & Wallen, 2006). In this respect, the result obtained is essential in interpreting the study results.

At the end of a 10-week experimental process, the NOSS and SKS, applied as a pre-test, were re-applied as a post-test. As a result of this application, when the control group's pre-test and post-test results are compared, there is a statistically significant increase in favor of the post-test. According to this result, it is seen that the explicit-reflective learning approach contributes to a positive change in pre-school prospective teachers' thoughts about the NOS and SK. It supports the results obtained from many studies in the literature. In many studies using the explicit-reflective teaching method, it was concluded that students, prospective teachers, and teachers learned the NOS better than other methods (Abd-El-Khalick & Lederman, 2000; Khisfe & Abd-El-Khalick, 2002). It is also stated that learning the nature of science has an important effect on understanding SK (Abd-El-Khalick & Lederman, 2000; Akerson & Abd-El-Khalick, 2005; Akerson & Hanuscin, 2007; Akerson & Volrich, 2006; Bell, Lederman, & Abd-El-Khalick, 2000; Khishfe & Abd-El-Khalick, 2002; Moss et al., 2001).

Besides, when the experimental group's pre-test and post-test results are compared, there is a statistically significant increase in favor of the post-test. According to this result, it is seen that the formative assessment embedded with the explicit-reflective learning method contributes to a positive change in pre-school prospective teachers' thoughts about the NOS and SK. In the literature, it is stated that formative assessment has a positive effect on students' learning, helps prospective pre-school teachers gain research skills, and students who gain scientific research skills reach scientific knowledge like scientists (Bonner, 2005; Harlen et al., 2003; Llewellyn 2002; Metin, 2014; Metin & Birişçi, 2009; Metin & Özmen, 2010). In this respect, it can be said that formative

assessment causes an increase in the pre-school prospective teachers' knowledge about the nature of science and scientific knowledge, and in this case, it positively changes their thoughts about NOS and SK. In addition, based on the statements that formative assessment increases research and inquiry skills, it is likely that pre-school prospective teachers will better understand the NOS, which is based on research and inquiry. It is inevitable that pre-school prospective teachers' acquisitions about the NOS and SK will also affect their opinions on this subject.

As a result of the research, it was determined that both the methods applied to the control group and experimental group caused a statistically significant change in the students' thoughts about the NOS and SK. This result causes us to ask the question "which method is more effective in changing the NOS and SK of pre-school prospective teachers?". When the post-test results of the experimental and control groups were compared, it was determined that there was a statistically significant difference between both groups and this difference was in favor of the experimental group. In addition, in order to test this result, the change between the pre-test and post-test results of both groups is examined in terms of effect size. A criterion that shows whether the difference between the results of the groups in the study is significant is the effect size (Cohen, 1988). Effect size can be expressed as the expected difference between two averages or two ratios according to the outcome variable of interest to reveal a clinically significant difference (Meline & Wang, 2004). In other words, the effect size is used to determine how much a new method makes a difference compared to the old one (Yıldırım & Yıldırım, 2011). When it was seen effect size score, it was determined that formative assessment embedded with explicit-reflective teaching instruction caused more positive changes in pre-school prospective teachers' thoughts about the NOS and SK than explicit-reflective teaching instruction (Table 7). According to this result, it can be said that when formative assessment and explicit-reflective teaching instruction are used together, the positive aspects of both methods combine to affect better learning of concepts such as the NOS science and SK.

It is essential but not sufficient for prospective pre-school teachers to learn the nature of science and scientific knowledge. For this, pre-school prospective teachers' thoughts on the NOS and SK must be permanent. It is important that they do not forget what they learned, even after a certain period of experimental intervention. For this, it is necessary to test the persistence of pre-school prospective teachers' Nos and SK. In order to determine whether the use of formative assessment with explicit-reflective instruction has a permanent effect on pre-school prospective teachers' thought on NOS and SK, the scales have been administered after four weeks. The results have shown a significant difference between experimental and

control groups. The students in the experimental group have had higher means than the pre-school prospective teachers in the control group. Besides, the comparison of retention tests with post-tests in both groups reveals that there is not a significant difference between the results of these tests in experimental and control groups. This result shows that formative assessment with explicit-reflective instruction has a permanent effect on pre-school prospective teachers' thought NOS and SK.

According to these results, it can be stated that the formative assessment embedded with Explicit-reflective instruction has more positively and permanently changed pre-school prospective teachers' views about NOS and SK than Explicit-reflective teaching instruction.

## CONCLUSION

As a result of the study, it was determined that both formative assessments embedded with Explicit-reflective instruction and Explicit-reflective instruction changed pre-school prospective teachers' thoughts about the NOS and SK positively and permanently. However; it was seen that the formative assessment embedded with Explicit-reflective instruction was more positively and permanently changed on pre-school prospective teachers' view about NOS and SK than Explicit-reflective instruction.

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