Educational Sciences: Theory & Practice • 14(1) • 353-372

www.edam.com.tr/estp
DOI: 10.12738/estp.2014.1.1979

How In-service Science Teachers Integrate History and Nature of Science in Elementary Science Courses

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Abstract

The purpose of this study is to investigate how the in-service science teachers' (IST) perceptions and practices about curriculum and integration of the history of science (HOS) and the nature of science (NOS) affect their science courses. For this aim, how ISTs integrated the NOS and HOS in their elementary science courses for understanding of the NOS, the results of this integration, and how the ISTs' NOS views influenced their science teaching practices were examined. In this phenomenological study purpose and criterion sampling methods were used. Nine ISTs constituted the sample of the study. A constant comparative method was utilized for the data analysis. Multiple data sources and different evaluators were used for triangulation. The current study revealed that all the teachers in the study do their best to implement the science and technological curriculum; however, the implementation of the curriculum is not at the expected level. Also our findings indicated that the teachers' views about NOS did not directly influence their educational practices. In addition, knowing how to teach NOS is an important factor for a teacher's transfer of their knowledge and understanding of NOS to their classroom, as well as the teacher's NOS views. In this process some possible problems such as creating misconceptions, not explaining the NOS aspects effectively, differences in the students' beliefs, individual differences, and problems in the classroom environment might emerge and negatively affect the teachers' integration of NOS and HOS.

Key Words

History of Science, In-service Teacher, Nature of Science, School Science Curriculum, Teaching Practices.

Theoretical Background Related to History of Science

The goal of science education is explained differently in literature. While Renner and Stafford (1972) consider that the aim of science education is to prepare students for effective citizenship, according to Hurd (1970) the major purpose of science education is to develop the scientific literacy of students which is defined as "the knowledge and understanding of the scientific concepts, and processes required for personal decision making" (Lawson, 1995, p. 17). In addition, Gerber, Cavallo, and Marek (2001) state that the fundamental aim of science education is to improve students' science literacy, help them develop an understanding of concepts and transfer them to a new situation when solving a problem. Several science education reformers have undertaken research into the integration of the nature of science (NOS) in curriculum development, and also have defined the goal of science education in different ways. Bybee and DeBoer (1994) summarized the goals

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of science education as "*1*) personal and social development, *2*) knowledge of scientific facts and principles, and *3*) scientific methods and skills and their applications" (p. 358). Cil and Cepni (2012) defined one of the goals of science education as helping students develop their awareness of informed NOS views.

In the American National Science Education Standards it was emphasized that the history of science (HOS) has an important role in the achievement of science education goals (Matthews, 1994; NRC, 1995; Seker, 2012). Teaching science integrated with HOS has been investigated by many researchers for over a century (Lin, 1998; Lin, Hung, & Hung, 2002; Matthews, 1994; Solomon, Duveen, & Scot, 1992). Solomon et al. (1992) describe the advantages of incorporating HOS in science teaching as "*a*) better learning of concepts of science, *b*) increased interest and motivation, *c*) introducing the philosophy of science, *d*) developing a better attitude of the public towards science and their understanding of the social relevance of science" (p. 410). Improving the conceptual understanding of students through the HOS has been explored by many researchers (Lin et al., 2002). In addition, Galili and Hazan (2001) classified the ways of utilizing the history and philosophy of science (HPS) into five categories. These are *a*) reproduction of historical experiments, *b*) providing students the authentic scientific texts or original publications, *c*) combining of stories and anecdotes, *d*) integrating HPS contents or materials in the course, *e*) a "Dates and Names" approach which incorporates references to inventors and discoverers who have significantly contributed to the scientific progress. Recently an instructional model for using the history of science (UHOS) was proposed by Seker (2012). The UHOS model includes conceptual, epistemological, sociocultural, and interest level related to teachers' ability to use historical knowledge in their science teaching. The conceptual level is connected to the learning objectives and related to the educational approach. The epistemological level is concerned with the understanding of the NOS. The sociocultural level concerns the relationship between science and society. Finally, the objectives and approaches regarding the effective domain comprise the interest level.

Related Literature regarding History of Science

Teaching HOS has been found to generally improve the understanding of NOS (Irwin, 2000; Seker, 2012; Seker & Welsh, 2006; Solomon et al., 1992). However, the effect of teaching the HOS on students' learning of scientific concepts remains controversial (Seker & Welsh, 2006). While some studies revealed that teaching HOS develops students' understanding of scienctific concepts (Lin et al., 2002; Seroglou, Koumaras, & Tselfes, 1998), findings of the studies showed that there is no improvement on students' understanding of scienctific concepts through the teaching of HOS (Irwin, 2000; Seker & Welsh, 2006; Solomon et al., 1992). In addition to these studies, there is other research on teachers and pre-service teachers. For example, Abd-El-Khalick (1998) investigated the influence of HOS courses on pre-service teachers' conceptions of NOS. Although the effectiveness of HOS on students' views of NOS had been supported by many researchers (Irwin, 2000; Seker & Welsh, 2006; Solomon et al., 1992), Abd-El-Khalick (1998) findings showed that HOS courses had little effect on pre-service teachers' NOS views. This limited influence may be explained through the lack of explicitly addressing certain NOS aspects within HOS courses. Another study (Wang & Marsh, 2002) investigated teachers' perceptions of the instructional role of HOS, and their practices of teaching science from an historical point of view. Data was collected from twelve teachers implementing HOS through an instructional survey, then five teachers were selected to be interviewed. The survey showed the HOS conceptual framework to promote three domains of understanding: conceptual understanding, procedural understanding, and contextual understanding. Wang and Marsh (2002, p. 180) detailed the domains as shown in Figure 1.

Figure 1.
HOS Conceptual Framework

Conceptual understanding	a) enriching the presentation of scientific knowledge
	b) emphasizing the tentative nature of scientific knowledge
Procedural understanding	a) process of thinking or thought experiment,
	b) process of investigation
	c) process of concluding, inferring, elaboration, reporting, and implementation
Contextual understanding	a) psychological factors involved in the science making (e.g., motivation, incentives, purposes)
	b) social factors (e.g., peer influences, public attitudes, social needs, or political factors that affect the scientist's action)
	c) cultural factors associated with scientific research (e.g., personalities, culture of family, organization, social, or ethics.)

The findings of this study revealed that teachers were more likely to incorporate historical elements regarding contextual understanding than with the other categories. In particular, teachers did not integrate procedural understanding into their syllabus. Teachers commented that since their curriculum was overloaded with topics they did not attach importance to inclusion of additional historical elements. Another study comparing elementary, secondary and student teachers' perceptions and practices related to HOS instruction was the extended version of a previous study (Wang & Cox-Petersen, 2002). The sample consisted of 43 elementary teachers, 8 middle school science teachers, and 21 high school science teachers. A HOS instructional survey was applied to these teachers. The findings of the study showed that teachers had different views with respect to the grade level they taught. Most high school teachers used HOS to promote the students' understanding of the content and their NOS knowledge. Also they used HOS to develop their scientific process skills. Most elementary teachers support the idea that HOS can help students' understanding the role of science in society, and increase students' positive attitude toward science. Therefore, these teachers teach the HOS for very different purposes.

Theoretical Background Related to The Nature of Science

Historians and philosophers in the field of science have proposed different approaches to the development of the curriculum, including fluid inquiry. Two examples of curriculum studies supporting the fluid nature of scientific inquiry are Schwab's Biological Sciences Curriculum Study (BSCS) and Klopfer's Harvard Case Studies in Experimental Science. These were valuable studies which supported including the HOS in the curriculum to promote NOS. In 1968 the history and philosophy of science, and science education were discussed by the National Association for Research in a science teaching symposium in Chicago. In the presented papers, some important considerations concerning NOS were presented. One paper proposed implementation of the History and Philosophy of Science in science education with a concentration only on the curriculum rather than having any focus on instructional design. Another paper paid attention to how the teacher's beliefs about NOS and the specific phrases they used in class influenced student understanding of NOS. This paper also supported the fluid or revolutionary nature of scientific knowledge (Duschl, 1993). Although some curriculum studies sought to improve student NOS, only focusing on the curriculum did not yield effective results (Lederman, 2007). Furthermore, many researchers realized that the teacher beliefs, explanations and performances were ignored and not considered as part of the curriculum. The most recent curriculum-reform studies address the NOS issue worldwide, in countries as disparate as Canada, Venezuela, Taiwan, Lebanon, and Turkey (Aslan & Tasar, 2013; Dogan & Abd-El-Khalick, 2008). In Turkey, since 2008 the current centralized science and technology curriculum was implemented nationwide and the vision of this standardized national curriculum for science and technology course emphasizes the importance of having scientifically literate students regardless of their individual differences (Hacieminoglu, Yilmaz-Tuzun, & Ertepinar, 2012; Ministry of National Education of Turkey [MoNE], 2008). One of the accepted major skills of being scientifically literate is the ability to understand not only basic scientific concepts, but also the nature and development of science and scientific knowledge. Thus, it is evident that understanding NOS is a key component in the development of scientific literacy in an individual (Dogan & Abd-El-Khalick, 2008; Lawson, 1995). Conceptions of NOS have changed with the developments of the history, philosophy, and sociology of science. The developments of these disciplines have brought about a change in the definition of NOS over the last century (Abd-El-Khalick & Lederman, 2000). Although NOS is closely related to the history and philosophy of science (HPS), they are not the same (McComas, Clough, & Almazroa, 1998). NOS has been described as "the epistemology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge" (Abd-El-Khalick & Lederman, 2000, p. 666). Specific aspects of scientific knowledge are tentative (empirically based), subjective (partly the product of human imagination and creativity), and socially and culturally embedded. Also making distinctions between observations and inferences, and understanding the relationships between scientific theories and laws are important aspects of NOS (Abd-El-Khalick, Bell, & Lederman, 1998; Khishfe & Lederman, 2006). Lederman (1999) pointed out that if the NOS objectives are discussed in an explicit way during instruction, this leads to a more successful improvement in the students' view of NOS. In Turkey, the new curriculum and textbooks emphasize the importance of NOS. Thus, in training seminars, teachers are introduced to these aspects of the curriculum and NOS. In the current curriculum some important features of the scientific method are emphasized including; observation, stating hypotheses, collecting data, testing hypotheses, rejecting or accepting hypotheses, and interpreting data. It is stated that imagination, creativity, objectivity, inquiry, and being open to new ideas are all important in scientific processes. In science and technology, education students should learn the ways of attaining knowledge through discovery, which involves the process of reconstructing their knowledge. In the curriculum it is also emphasized that knowledge in science today is not fixed but is the best explanation currently known. When these features are considered, the new science and technology curriculum in Turkey embraces a constructivist approach whereas the previous science curriculum was student-centered and focused on the scientific method and investigation processes. One of the most important differences between the previous and new curricula is that the former had a linear structure and the latter has a spiral structure (Cil & Cepni, 2012; MoNE, 2008).

Related Literature regarding Nature of Science

As a result of the worldwide integration of NOS in the curriculum, determining teachers' views about NOS and their instructional practices has gained a high priority for science education and the researchers (Abd-El-Khalick et al., 1998; Brickhouse, 1990; Chen, 2001; Chun, 2000; Gallagher, 1991; Lederman, 1999). Tuan and Chin (1999) supported the importance of a teachers' desired level of NOS understanding and transferring their understanding to students through effective instructional practices in order for students' to become scientifically literate people (Aslan & Tasar, 2013). Some researchers support the idea that teachers' beliefs about NOS directly influence their educational practices (Brickhouse, 1990; Gallagher, 1991; Palmquist & Finley, 1997). In one such study Gallagher (1991) conducted a qualitative study to determine the relationship between beliefs about science and teachers' classroom practices. The results showed that teachers' beliefs about science influence their classroom practice. However, teachers' beliefs about science are limited to the structure of scientific knowledge. Therefore, teachers were not able to emphasize the tentative and creative NOS in their classroom practice. On the other hand, other researchers do not agree about this idea and consider that teachers are not able to transfer their NOS views to their classroom practices. Thus, teachers' educational practices are not related to their NOS views, (Abd-El-Khalick et al., 1998; Aslan & Tasar, 2013; Chen, 2001; Chun, 2000; Lederman, 1999; Mellado, Bermejo, Blanco, & Ruiz, 2007). In one of these studies, Abd-El-Khalick et al. (1998) investigated how teachers reflect their NOS views in their classroom practices. The sample of this study consisted of 14 pre-service science teachers and the results indicated that pre service teachers' (PST) NOS views are at a reasonable level, at least for five aspects. However, they were not able transfer their NOS understanding to their classroom practice. Therefore, it is important to educate PST not only to improve their NOS understanding but also in how to teach NOS. Another study conducted by Lederman (1999) explored the relationship between teachers' NOS views and classroom practices, and the factors influencing their classroom practices. The case study included 5 biology teachers whose teaching experience varied from 2-15 years. The results of the study indicated that more experienced teachers' classroom practices were more compatible with their beliefs since these teachers had improved the integration of their skills into practice. The other study investigated the NOS views of 13 PST and whether they had transferred their views into their teaching practices (Bell, Lederman, & Abd-El-Khalick, 2000). They believed that in order to integrate NOS to classroom practices, PST's should receive education pertinent to NOS and be taught how to teach NOS. Therefore, if NOS was taught to PST through an explicitly reflective approach, then they would be able to teach NOS in their method course. The results showed that PST's were not able to transfer their NOS views to their classroom practices and furthermore, teachers did not mention NOS in their lesson plan.

The other important issue is that teachers' instructional practices should be investigated, considering not only their NOS views, but also taking account of other factors (Aslan & Tasar, 2013; Chun, 2000; Duschl & Wright, 1989; Lederman, 1992). In one of these studies Duschl and Wright (1989) researched the impact of teachers' views about NOS on their instructional method and plan. The results showed that these teachers did not take NOS into consideration or placed little emphasis on it when planning and teaching. Furthermore, findings revealed that teachers had insufficient knowledge about NOS and also that it could not be taught to students because of factors related to the students and the curriculum. Another study was conducted with 6 science teachers by Chun (2000) who explored the implementation of science course activities and the teachers' NOS views. The data collected was analyzed considering different factors related to teachers' behavior. The findings revealed that most of the teachers had naive views for most aspects of NOS. The sources of their NOS views were their science textbooks, other sources they use for the science course, and their teaching experience, rather than from their academic education. They were not familiar with the NOS terminology in the literature and were unsure what they believed about the terms. Therefore, researcher did not obtain evidence related to the relationship between the teachers' beliefs and classroom practices. The results also showed that beliefs about the teaching and learning process, teacher and curriculum characteristics, the teaching method that the teacher selects, requirements for student's to graduate, and expectations of school administrators should be investigated together with teachers NOS beliefs to obtain more insight. A recent study conducted in Turkey by Aslan and Tasar (2013) investigated science teachers' NOS views, their practices and how their views affect their instructional practices. To determine teachers' NOS views, 18 items were selected from the Views on Science, Technology and Society (VOSTS) questionnaire and administered to 74 in-service science teachers. Then, five of the teachers were selected to be interviewed and observed in their classroom to obtain detailed information about their instructional practices. The results of the study showed that most of the teachers had naive views about NOS and that the five teachers who were interviewed held traditional views about NOS. Furthermore, it was revealed that the teachers' classroom practices were not directly influenced by the teachers' NOS views. However, there were other factors affecting teachers' classroom practices such as the high school exam, expectations of school administrators, parents and students in relation to the national exam (SBS). Teachers thought that since NOS topics are not in the curriculum then students were not expected to answer questions on these topics in the nationwide exams.

Rationale and Purpose of this Study

Firstly, although many studies have investigated teachers' views about NOS, only a limited number of studies have examined teachers' NOS views with their instructional practices, especially in Turkey. Secondly, the literature studies revealed contradictory findings regarding the relationship between teachers' views about NOS and their educational practices (Aslan & Tasar, 2013; Palmquist & Finley, 1997). Additionally, teachers' perceptions and instructional practices should be investigated with consideration of the teacher's characteristics and the factors affecting the teacher's classroom practices, as well as their NOS and HOS views in various contexts. As a result, this study selected teachers having different characteristics as a sample, taking into account the previously mentioned factors to see the results in a wider perspective. In conclusion, the purpose of this study is to investigate the in-service teachers' perceptions and practices about curriculum, and the integration of HOS and NOS in their science courses. This qualitative study was carried out to answer the following specific questions:

- What are the in-service teachers' perceptions and practices regarding implementation of the curriculum and integration of HOS and NOS in their elementary science courses?
  - o How do in-service teachers integrate HOS and NOS in elementary science courses?
  - o How do in-service teachers explain the results of the integration of HOS and NOS?
  - o How do in-service teachers' NOS views influence their science teaching practices?

Method

Research Design and Sampling Procedure

A phenomenological approach was used. This offers a descriptive, reflective, interpretive, and engaging mode of inquiry from which the essence of an experience can be derived and then used to explain 'how phenomena are experienced by participants' (Bogdan & Biglen, 1998). In this study a specific phenomenon of the in-service science teachers' perceptions and practices about curriculum and integration of HOS and NOS in their science course was investigated. Specifically for this aim, ISTs' integration of NOS and HOS in elementary science courses for understanding of NOS, the results of this integration, and the influence of ISTs' NOS views on their science teaching practices were examined. In order to undertake this study two sampling methods were used. First, purposeful sampling (Patton, 1990) was used since the participating teachers needed to be those that believed they were effectively applying the current

Turkish elementary curriculum. They volunteered to have their classroom instruction recorded and they allowed themselves to be interviewed. After the purposeful sampling, nine teachers whose classes would be studied were selected using the criterion sampling method (Patton, 1990): according to the school type, years of teaching experience, location of the school and whether they took courses regarding NOS in undergraduate education. Of the nine teachers, three worked in private schools with high socioeconomic status but they had not taken courses regarding NOS in undergraduate education. Three worked in public schools (one in a poor village and the other two in a central district of a city) but they had taken courses regarding NOS in undergraduate education. The final three taught in a public school but had not taken NOS courses in their undergraduate education. Three teachers (one from each group) were employed in Ankara, the capital. 4 worked in other cities, and the final 2 taught in village schools in Turkey. The information about the in-service teachers' characteristics is summarized in Table 1.

Table 1.
Characteristic of Participants

Participant	Gender	School Type	Teaching experience (years)	Location they work and SES of School	NOS Course
T 1	Male	Private	12	Central district (high SES)	Not taken
T 2	Female	Private	6	Central district (high SES)	Not taken
T 3	Female	Private	10	Central district (high SES)	Not taken
T 4	Female	Public	4	Village (low SES)	Taken
T 5	Female	Public	5	Central district (medium SES)	Taken
T 6	Male	Public	3	Central district (medium SES)	Taken
T 7	Male	Public	6	Central district (medium SES)	Not taken
T 8	Female	Public	12	Central district (medium SES)	Not taken
T 9	Female	Public	5	Village (low SES)	Not taken

T: Teacher

Data Sources

In the first step, Views of NOS Questionnaire -C (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002), HOS instructional survey (Wang & Marsh, 2002) and follow up interviews were used to investigate the in-service teachers' views about NOS and their perceptions regarding HOS instruction.

The HOS Instructional Survey: Developed by Wang and Marsh (2002) was translated and adapted to Turkish Hacieminoglu, Ertepinar, and Yilmaz-Tuzun (2012). This survey uses the 5-Likert type scale consisting of 26 items. 13 items measure perceptions. Of the other 13 items, 4 are related to the conceptual domain of understanding, 3 to the procedural domain of understanding and 6 items are related to the contextual domain of understanding for both their perceptions and practices.

The Views of NOS Questionnaire –C: Developed by Lederman et al. (2002) was translated and adapted into Turkish by the Hacieminoglu, Yilmaz-Tuzun, and Ertepinar (2009). The original items and their translated versions were examined by two English language experts and an associate professor, who is an expert on the NOS. The questionnaire contained 10 open-ended questions covering aspects of NOS as follows: Empirical NOS; the meaning of scientific experiment; belief that scientific knowledge requires experiment; tentativeness of theory; law and theory difference; inference, theoretical entities, and creativity of atoms; inference, theoretical entities, and creativity about species; theory laden NOS; socio-cultural influences; and the role of imagination and creativity. After completing the questionnaire the teachers were categorized as having naïve (Nv), transitional (Trs) and informed (Inf) views about all aspects of NOS. The information about in-service teachers' NOS views and the sources of teachers' awareness about NOS is summarized in Table 2.

In order to obtained in-depth information about the phenomenon, the following sources of information were used: classroom observations, semi-structured interviews and written documents as described below.

For the classroom observation, all nine teachers were videoed giving instruction on the same subjects (the Structure and Properties of Matter Unit for 7th grade level). Teachers and students all consented to the video recording in the classroom.

A standardized open-ended interview was used in this study. Therefore, the exact wording and sequence of questions was determined in advance. All interviewees were asked the same basic questions in the same order. Questions were worded in a completely open-ended format. The duration of the interviews was about 45-55 minutes, and all the interviewees responses were transcribed for data analysis. For the validity of the interview questions, the opinions of a qualitative research expert and a science educator were obtained. A pilot study was conducted to determine the interview schedule (Hacieminoglu, 2013).

Table 2.
Participants NOS Views and Sources of Teachers' Awareness about NOS

Teachers' Views	Participants								
	T 1	**T 2**	**T 3**	**T 4**	**T 5**	**T 6**	**T 7**	**T 8**	**T 9**
Teachers' NOS Views									
Tentative	Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf
Empirically Based	Nv	Nv	Nv	Inf	Inf	Nv	Trs	Trs	Trs
Subjective	Trs	Trs	Nv	Inf	Inf	Trs	Trs	Trs	Trs
Imagination Creativity	Nv	Inf	Nv	Inf	Inf	Trs	Trs	Trs	Trs
Socially Culturally Embedded	Trs	Trs	Trs	Inf	Inf	Inf	Inf	Trs	Nv
Observation and Inferences	Nv	Nv	Nv	Inf	Inf	Trs	Nv	Trs	Nv
Theories and Laws	Nv	Nv	Nv	Inf	Inf	Trs	Nv	Nv	Nv
Sources of teachers' awareness about NOS									
NOS Course in undergraduate education				*	*	*			
Method Course integrated with how teach NOS				*	*				
Graduate Education									*
Conferences and Workshops									*
In-service teacher training	*	*	*	*	*	*	*	*	*

*= Mentioned about the issue

The third data collection technique was document analysis. The teachers' lesson and activity plans for the *Structure and Properties of Matter Unit,* and other documents used by teacher in the classroom such as project and performance assignments were reviewed and analyzed.

Validity and Reliability

To ensure the trustworthiness of the data it was collected over an extended period of time (during approximately four to five weeks). Multiple data sources (interviews, observations, and written documents) and different evaluators were used for triangulation. For the validity of the interview questions, the opinions a qualitative research expert and a science educator were elicited. Also raw data in the form of direct quotations is presented without any interpretations. To ensure reliability, the codes were discussed with a qualitative research expert and science educator (second coder). The inter-rater reliability of the interviews and observations was 80% and full agreement for all the codes was achieved through discussion between the first and second coders.

Data Analysis

Once the overall strategy, sampling procedure and the data collection methods have been determined, the data obtained for the research study should be recorded, managed, and analyzed (Marshall & Rossman, 1999). Patton (1990, p. 372) maintains that "there are no formulas for determining significance, there are no ways of perfectly replicating the researcher's analytical thought process, and there are no straightforward tests for reliability and validity". Thus, the data analysis procedure is a flexible and potentially an ongoing process for which there are no strict rules. A constant comparative method (Glaser & Strauss, 1967; Strauss & Corbin, 1990) was used for the data analysis. For this study, in constant comparative method, the researcher first mainly collected the initial data and then carried out the analysis based on the transcriptions of the interviews with the teachers and the classroom observation sheet. In an open coding process each unit of data was grouped under a category according to the shared common characteristics. The researcher categorized and identified themes with the similar characteristic of categories in an axial coding process. As certain patterns formed, themes emerged and in the selective coding process the researcher tried to give meaning to these synthesized patterns and threads. As mentioned above, these codes were drawn from both the literature and the researcher's experience and may change throughout the analytical process, however, the main criterion in coding is the most salient aspect of the units of analysis. Video records were also analyzed following the same procedure in light of the codes obtained from interviews.

Results

Results of Analysis of Interview Transcripts

Nine interviews were conducted with nine teachers who work in the elementary schools to investigate in-service teachers' integration history and NOS in elementary science courses. After the data was collected and analyzed, the following five main themes emerged: implementation of the science and technology program, integration of NOS, measurement of NOS, integration of HOS, and problems in the integration process of NOS and HOS. The codes from the following five main themes are summarized in Table 4.

Implementation of a Science and Technology Program

One of the themes is the implementation of a science and technology program. Teachers reported that they had positive attitude towards the new curriculum and they tried to apply curriculum in their classroom depending on facilities and grade level. In some classes teachers focused on student centered teaching with active participation, in other classes they preferred to use teacher centered activities such as demonstration, animation, and video because of the large number of students in the classroom. Most of the teachers emphasized that they preferred to use demonstration not to lose control of the students in the classroom. Moreover, teachers generally could not obtain the materials that were necessary to undertake all the activities in the program. The following quotes are representative views of the teachers with different characteristics;

> T 2: "In our school, considering the objectives and curriculum, we update our lesson plans every year. According to goals and objectives the other science and technology teachers and I plan all the activities ourselves. Since the dynamics of the student group and characteristics change every year, we change and update our plans and activities according to the students' level to achieve students' complete learning. Facilities such as laboratory and materials support our plans related to student centered activities".

> T 5: "I am trying to apply the science and technology curriculum considering the objectives properly. I have the students do student centered activities, if the number of the students is suitable for this. For example, in seventh grade classrooms, I let students do almost all of the activities in curriculum. These student-centered activities certainly support the students' meaningful learning. However, in sixth and eighth grade classrooms, because of the large number of students I do activities that are teacher centered or demonstrations. Also a lack of time and materials might be problem for undertaking student centered activities. When I believe that I can't control the class, I use such activities as videos and animations".

> T 8: "I totally support the effectiveness of student-centered activities but I could not have students do them in classroom because of the lack of materials, not to lose control of the class, and large number of the students in classroom. For example, our science laboratory is very small and materials are not enough for active participation for all the students."

Under the implementation of the new program all the teachers think that it is impossible to put into practice all the learning from their undergraduate courses in a real class because of the number of students and other factors such as lack of materials, student's low academic level, and also parents of students. The following quote is representative of these views;

> T 4: "Because of the facilities and [large] number of students, I could not prepare an environment in which the students could do experiments on their own. I admit honestly that I enrich the courses with visual documents, but I could not establish a learning environment that supports active learning. When I try to activate students in the science courses, I lose control of the students. On the other hand in a classroom with a small number of students, I put in to practice all my learning from my undergraduate method courses related to teaching, especially the 5E method. For instance, I use role play (I tested effectiveness of this method). I also provide for the students to carry out experiments. I have students undertake inquiry and group working. I teach science courses through animations, videos and posters. I let students self-assess."

Integration of NOS

In terms of integration of NOS; Teachers reported that they focused most on tentativeness, cultural embededness and the imagination-creativity aspects of NOS. Teachers also least emphasized scientific theories and laws related to NOS giving the reasons that scientific laws and theories are not mentioned in most subjects in the science and technology program. Teachers integrated NOS in their science classroom explicit, explicit-reflective, and implicit ways. They also used HOS to promote NOS and activities related to NOS. It is important to explain some misunderstanding related to explicit and reflective concepts. Abd-El-Khalick (2012) explained that explicit should not be perceived as direct or didactic instruction. Basically "explicit" refers to curricular components, while "reflective" refers to instructional implications. Reflections center on questions regarding characteristics of scientific knowledge.

Findings revealed that T 5 and T 4 emphasized NOS using an explicitly reflective approach. They also used activities and a historical approach with reflective questions to emphasize the NOS aspect. Teachers considered that through the integration of NOS into the curriculum, students gained questioning skills, improved their awareness of NOS, increased their self-efficacy, and thought about the questioning of scientific knowledge.

> T 4: "Integrating NOS aspects in related subjects is one of the most important objectives in the science course since students' awareness about NOS is gained from curiosity and using an inquiry approach when doing their investigations. In fact, the NOS can be emphasized in each stage of the science courses. Most of the activities in the curriculum assist students in estimation – observation – inference. Firstly I ask questions to activate students' minds and encourage students' to think during activities or experiments. Then I ask students reflective questions until students come to understand the NOS aspects. Furthermore, I make the students aware of the ideas related to scientists' inferences, the subjectivity and tentativeness of scientific knowledge through the historical process in science textbooks."

> T 5: "There are no activities in the curriculum for the direct achievement of the NOS objectives. In fact I am not really sure if NOS should be considered a subject or topic of science, since the purpose of NOS is to develop a point of view about science, it makes more sense to address it together with the science subjects. However, there are some activities we have done to achieve an understanding of NOS. For example, in terms of the subjectivity of NOS, a scientist formed a square while another scientist formed a rectangle using the same materials. Since the science program is quite overloaded, I am not able to catch up with the objectives in the curriculum. Therefore, we carry out activities that directly aim for achievement of NOS understanding in social club classes, not in the [formal] science and technology classes."

T 6 and T 9 attempted to address NOS explicitly and directly rather than using the explicit- reflective approach. They have intention of emphasizing NOS and they have objectives related to NOS in their curriculum goals. These two teachers commented on the tentativeness, empirically based and subjectivity aspects of NOS aspects as orally in classroom.

> T 6: "I introduce scientists and scientific studies during [the students'] discoveries. I am trying to integrate the tentativeness, empirically based and subjective aspects of NOS. I emphasize that scientific knowledge is influenced by socio-cultural factors. I say that scientific knowledge can change in the future and it can be developed through the accumulation of scientific knowledge and more evidence. Scientists benefit from previous scientists' findings and add new elements to these findings. I emphasize these aspects during the activities. Also I am saying that scientific knowledge can be proved by evidence."

On the other hand T 7 and T 8 used an implicit approach rather than explicit or explicitly reflective approach. Also T 1, 2, and 3, working in private schools and organizing many activities for students, used an implicit approach to emphasize the aspects of NOS. They intended that students gain the aspects of NOS and use student centered activities as suggested in the curriculum but learners are expected to develop their own NOS understanding by themselves. For example, students are expected to come to an understanding about how scientific knowledge changes through the activities. The following quotes are representative views of the teachers with different characteristics:

> T 2: "For example, in one of the units I asked my students to close their eyes and imagine the things they can do in the darkness. Then think about ancient times and scientists' contribution about light during the historical process. We discuss the history of the development of lighting and devices which are a source of artificial light and the scientists that invented them."

> T 7: "I give examples from scientists' lives. On completion of the experiments, students explain ideas differently and they make

different inferences. In this way they can reach subjectivity about scientific knowledge. Students can understand the importance of evidence and obtaining scientific knowledge through project-based assignments."

Measurement of NOS

Teachers used some measurement strategies to assess students' awareness of NOS. These were right / wrong type questions, interpretation questions, classroom performance, questioning students' reflection after the activities, inference questions following multiple choice options, using misleading questions, student design experiments and project-based assessment. All the teachers, except for T 4 and T 5, mostly used a question and answer method to measure the understanding of NOS and less often undertook a performance-based assessment approach. The teachers working in private schools observed the performances of the students in laboratories to assess their awareness about NOS.

T 2: "I observe students in their free work in the laboratory."

T 4: "As I mentioned, the aspect we emphasize most is that scientific knowledge can change. When I ask the students reflective questions, I see that they do not think science is static. Students say that what we know now can change over time and they even give their opinions about what might happen. This allows me to see if they have developed awareness. In addition, when the students observe or try something new (such as experimenting and designing), they are enthusiastic to share their experience with me. That is how I can tell they have developed the awareness that scientific knowledge is acquired through experimenting."

T 5: "Performance-based assessment and interpretive and reflective questions after the activities supply meaningful learning for the students. If they learn meaningfully they can remember and use their learning in new situations whenever the need arises. For example: when I was teaching atoms to the sixth grade students, I laid great emphasis on the aspects in relation to NOS. There was a question about this in the SBS test at the end of the year. I was quite happy to hear that most of the students had answered that question correctly. The question was:

Ceyda made research about the historical development of atoms and summarized it as follows:

- About 400 B.C. Democritus suggested that all matter was composed of a single type of atom.
- In the 19th century Dalton proposed that the atoms of different elements had different properties.
- Today it is accepted that atoms are composed of smaller particles, and the research on atoms is still ongoing.

Which of the following statements can be inferred from the summary above? (2009- 6th grade SBS):

A) All the opinions about atoms are still valid.

B) What we know about atoms has changed over time.

C) Today we do not have any knowledge about atoms.

D) All scientists have the same opinion about atoms."

T 9: "I ask the students contradictory questions to determine their level of awareness. I come up with an explanation that contradicts with the NOS and see if they have picked up on my

Table 3.

The Teachers' Views about Perceptions and Practices regarding HOS Integration

Teachers' Views about Participants	INST 1	INST 2	INST 3	INST 4	INST 5	INST 6	INST 7	INST 8	INST 9	Total
Perceptions regarding HOS integration (Mean)										
Conceptual understanding	4.42	4.36	4.32	4.72	4.66	4.20	3.96	3.74	4.14	**4.28**
Procedural understanding	4.35	4.66	4.40	4.30	4.32	4.26	4.28	3.25	4.07	**4.21**
Contextual understanding	4.10	4.24	4.08	4.54	4.46	3.84	3.75	3.73	3.46	**4.02**
Practices regarding HOS integration (Mean)										
Conceptual understanding	4.38	4.28	4.32	4.66	4.54	4.03	3.88	3.66	4.24	**4.22**
Procedural understanding	4.24	4.42	4.18	4.35	4.46	4.00	4.00	3.00	4.28	**4.10**
Contextual understanding	4.00	4.00	4.10	4.24	4.20	3.46	3.55	3.50	3.26	**3.81**

mistake. I measure the awareness of the students by measuring their level of noticing these mistakes."

Integration of HOS

Table 3 showed that teachers' views about perceptions and practices regarding HOS integration were all at a reasonable level. In their teaching practices of HOS they emphasized mostly conceptual understanding and the least emphasis was given to contextual understanding. Teachers reported that they emphasized tentative nature of scientific knowledge the most through the HOS in science courses. Observation results also supported this finding. Teachers used HOS especially while teaching the structure of the atoms. Some of them gave students a project about scientists' lives and their scientific projects. The results of the teachers' views about perceptions and practices regarding HOS integration are shown in Table 3.

In the interview the teachers were asked how and why they integrated HOS in their science class. The teachers replied that they applied HOS in the classroom with activities, through role playing, storytelling, drama, discussion, and direct teaching. Teachers said they integrated HOS to improve NOS aspects such as tentativeness, subjectivity, cultural embedding and to develop the awareness that a scientist is no different from other people.

T 2: "We use HOS, but not for all subjects. For example, we made a history chart about the ways of illumination. In addition, when we talk about the moon and the earth, we also talk about Galileo, about how the first people on earth were interested in the stars as a result of the conditions of the era they lived in. Our objective is to make students understand that science emerged from necessities and develop the awareness that a necessity can lead to new technologies and new information. I believe that this way of steadily providing information makes the new information long-lasting. It also gives students the self-confidence to engage in scientific thinking. Thus, students are motivated to think, and to discover new things whenever they need something."

T 5: "I use HOS to show the students that scientific knowledge can change. The book we use gives information about HOS, however, straight facts limit the creativity of the students. When we show the students that knowledge can change, they acquire a more subjective and self-confident scientific approach. For example, in relation to a lesson about atoms for 7th grade students, I give the students roles and ask them to act out the discussion."

T 9: "I use HOS. We mostly review the chronologies and comment on the inventions step by step. The reason why I use HOS is to let the students know that the modern theories accepted today have been formed using the research done in the past. This way they get to understand that a small research project today can be the resource for a great invention in the future."

Problems related to the Integration Process of NOS and HOS

One of the problems in the integration process is related to misconception. The teachers thought the reason for this misconception is the lack of explanation regarding NOS in the textbooks, teachers' language and inadequate knowledge about NOS, or students' previous misconceptions.

T 5: "Students may have misconceptions in this process. Once students understand that scientific knowledge can change, they begin to think that scientific knowledge is not reliable and it is more difficult to make them believe that it actually becomes more reliable. This results from the statements of the teachers not being well thought out or the previously formed misconceptions of the students."

T 9: "Teachers should be very careful about what they say in the class since any misstatement can result in a misconception about the NOS. First of all, I believe that teachers, including myself, are inadequate in terms of NOS and teaching it. I do not know how much importance is given to NOS in the [university] faculties at the moment but before 2006 teachers did not know about this subject and the related concepts. There are also no in-service training programs about NOS."

Another problem relates to the teaching of all aspects of NOS. Teachers thought that they could not explain all the aspects of NOS. The reason for this is related to limited time, lack of materials, overloading curriculum, and the teachers' inadequate knowledge.

T 9: "One of the biggest problems I have is that we are not able to address all aspects of NOS. For example, we can discuss that scientific knowledge can change but verbally stating that science is based on imagination is not very satisfactory. Students need to use open-ended experiment techniques to comprehend it; however, these techniques require much time and materials."

T 4: "I am not able to fully integrate NOS into all subjects. I am limited to some aspects of NOS because of the overloaded curriculum."

T 8: "When teaching NOS, we are not able to use the open-ended experiment technique frequently enough to allow the students to interpret the results of experiments since the number of science and technology classes is not enough and the curriculum is quite overloaded. In addition, I believe that teachers do not have enough knowledge about NOS and how to teach NOS."

On the other hand even if teachers have high efficacy and motivation about teaching NOS, they would not be able to give importance about emphasizing NOS for all subjects because of parents' expectations and school administration regarding SBS.

T 5**:** "When the occasion arises we explain the other aspects of NOS (for example, that science can be affected by subjectivity and cultural differences); however, most of the time I have to focus on preparing the students for the SBS rather than reinforcing their perceptions about NOS since they can build a good future getting high scores from the SBS, and parents and school administration are mostly interested in the SBS scores of the students."

The other problems are students' beliefs about scientists and individual differences, such as learning level, learning style, prior learning. For example, one teacher commented:

T 7: "Students think that a scientist is very different from students. This belief decreases the self-confidence of the students and as a result they do not think what they produce is important. They do not believe they can also be scientists in the future. This has a negative impact on meaningful learning. Some of the problems students face result from their tendency to memorize, their inability to establish cause and effect relationships and to make interpretations."

Furthermore, teachers said that because of the low academic level of students, insufficient prior learning, and students' different interests, teaching NOS aspects sometimes becomes difficult and stays in the background.

T 5: "I think NOS understanding is a high level achievement for the students. I cannot teach NOS to every class in the way I wish. My practices change according to the level of the students. In some classes I have to simplify the concepts and in others, students can make logical deductions since they have previous knowledge about NOS. For example, one of my classes (7B) consists of 18 students with good grades. It is therefore possible for me to create a favorable environment in which to teach NOS."

T 8: "Not all students should receive the same level of science and technology education as in our curriculum. Every student has different interests. I think we are wrong in trying to get them to the same level. It is difficult to teach genetics to a student who is not interested in science. Students who are not interested in science disturb the class. They don't bring their notebooks and books to the classroom. Therefore, it is more difficult to get these students to achieve the NOS objectives."

Another problem is related to classroom environment such as large numbers of students, and losing students' control. Teachers reported that a large number of students in the class reduces the amount of students' actively learning.

T 9: "The classroom should be a place where the students are actively involved in experiments, ask questions and participate in discussions. Unfortunately, we are not able to create this atmosphere in our schools."

T 4: "The large number of students in a class restricts active learning and the roles of the teacher and students. It means spending more time for the management of the class and less time on encouraging the students to think and question. Managing the class is sometimes so difficult that the discussions go off track."

Discussion and Conclusion

Assertions from the findings represented above is discussed and concluded as follows:

Assertion regarding Implementation of New Program

All the teachers in this study do their best to implement the science and technology curriculum, however, the implementation of the curriculum is not at the expected level due to factors such as:

Table 4.
The Codes Obtained from the Main Themes

Teachers' Views	**Participants**								
	INST 1	**INST 2**	**INST 3**	**INST 4**	**INST 5**	**INST 6**	**INST 7**	**INST 8**	**INST 9**
Application of Science and Technology Program									
Positive attitude toward new curriculum	*	*	*	*	*	*	*	*	*
Keeping to the course objectives in curriculum	*	*	*	*	*	*	*	*	*
Different application in different grade level and different class according to the classroom environment	*	*	*	*	*	*	*	*	*
Student centered activities	*	*	*	*	*	*	*	*	*
Teacher centered activities	*	*	*	*	*	*	*	*	*
Encouraging students' active participation	*	*	*	*	*	*	*	*	*
Using Demonstration				*	*				
Using Video and posters					*				
Doing Experiment in laboratory	*	*	*	*	*	*	*	*	*
Discussion	*	*	*	*	*	*	*	*	*
Animation					*				
Role playing						*			
Problems related to Application of Program									
Students' individual difference (different student level, student previous knowledge),	*	*	*	*	*	*	*	*	*
Insufficient laboratory environment				*	*	*	*	*	*
Lack of materials				*	*	*	*	*	*
Overloading curriculum	*	*	*	*	*	*	*	*	*
Limited time	*	*	*	*	*	*	*	*	*
Large number of students in class				*	*	*	*	*	*
Losing control				*	*	*	*	*	*
Expectations of student parents	*	*	*	*	*	*	*	*	*
Integration of NOS									
Using HOS	*	*	*	*	*	*	*	*	*
Explicit						*			*
Explicit reflective				*	*				
Implicitly	*	*	*				*	*	
Activities related to only NOS objectives					*				
Measurement of NOS									
Right / wrong type questions	*	*	*	*	*	*	*	*	*
Interpretation questions/Reflective questions	*	*	*	*	*		*	*	
Observing classroom performance				*	*				
Their reflection after the activities				*	*		*		
Inference questions following multiple choice options				*					
Designing experiment	*		*		*				
Using Misleading Questions					*				*
Project based assessment		*		*	*				
Integration of HOS									
Through role playing					*				
Through story telling				*		*			
Through drama						*			
Through discussion	*	*	*	*	*	*	*	*	*
Through direct teaching							*	*	
To emphasize tentativeness	*	*	*	*	*	*	*	*	*
To emphasize subjectivity					*				
To emphasize social-cultural embedding					*				
To emphasize developmental nature of scientific knowledge									*

Table 4.
The Codes Obtained from the Main Themes

Teachers' Views	**Participants**								
	INST 1	**INST 2**	**INST 3**	**INST 4**	**INST 5**	**INST 6**	**INST 7**	**INST 8**	**INST 9**
Students learning meaningfully		*							
Historical process of scientific inventions		*		*	*	*			*
Importance of accumulation of knowledge									*
Feeling that a scientist is not different from other people				*	*		*		
Students understanding on scientists' lives and the time scientists live						*			
Problems in the integration process of NOS and HOS									
Causing misconception									
Lack of explanation regarding NOS	*	*	*	*	*	*	*	*	*
Teachers language	*	*	*	*	*	*	*	*	*
Students' previous misconceptions	*	*	*	*	*	*	*	*	*
Teachers' inadequate background	*	*	*			*	*	*	*
Not emphasizing all NOS dimensions									
Limited time	*	*	*	*	*	*	*	*	*
Lack of materials				*	*	*	*	*	*
Overloading curriculum	*	*	*	*	*	*	*	*	*
Inadequate knowledge of teachers	*	*	*				*	*	*
Expectation of parents and school administrations regarding SBS (National exam)	*	*	*	*	*	*	*	*	*
Students' beliefs and individual differences									
Students' learning level				*	*	*	*	*	*
Students' learning style				*	*	*	*	*	*
Students' belief related to scientist							*	*	*
Problems related to classroom environment									
Large number of students				*	*	*	*	*	*
Losing students' control				*	*	*	*	*	*

*= Mentioned about the issue

individual differences of the students (different levels of the students depending on their prior learning), lack of materials, expectations of the parents, difficulty for teachers managing overcrowded classrooms, limited time, overloaded curriculum, and inadequate laboratory environment. In addition, the teachers reported that they could not apply all the methods they learned during the undergraduate methodology courses. For example, these teachers could not use the 5E learning cycle model in a real class due to the lack of materials and the large number of students. Teachers with 2 to 5 years of professional experience reported that they have difficulty in managing their class, and teachers with more than 5 years of experience complained that their undergraduate studies failed to provide them with sufficient information about the new approaches in the science and technology curriculum. Furthermore, in-service training about these approaches were also inadequate. Before 2006 the teacher education curriculum approved by the Higher Education Council did not include new approaches such as NOS thus, teachers who graduated before this time do not feel confident about the implementation of these approaches. On the other hand, teachers working in private schools not only follow the science and technology curriculum but also modify the curriculum and activities every year in accordance with the student profiles, and suggest alternative activities. Contrary to the criteria for the assessment of state-employed teachers, the criteria used to assess the performance of private school teachers encourages them to engage in a wider range of activities. In addition, private school teachers have the advantage of not having problems such as insufficient materials and overcrowded classrooms. Dogan (2010) revealed similar findings to those in the current study. Although Dogan (2010) also found, teachers' attitudes towards the science and technology program did not differ with respect to their experience, in our study new teachers appeared to feel more confident than the experienced teachers about the implementation of science and technology curriculum.

Assertion regarding Awareness and Integration of NOS

The current study revealed that teachers' views about NOS do not directly influence their educational practices. Most of the studies support this finding (Abd-El-Khalick et al., 1998; Aslan & Tasar, 2013; Chen, 2001; Chun, 2000; Lederman, 1999; Mellado et al., 2007). Furthermore, in terms of the teachers' classroom practices there are different characteristics. The results of the interviews show that T 4 and T 5 undertook the approach of explicit reflective NOS instruction. During their undergraduate studies, these teachers took theoretical courses about NOS and methodology courses that provided them with information on how to teach NOS, and they were encouraged to implement what they learned. Moreover, in the methodology courses (in the 7th semester) these teachers were obliged to integrate at least one aspect of NOS into their lesson plans, objectives and practices in peer-teaching. Therefore, these teachers had the opportunity to see many examples of the integration of NOS with the science subjects of the 6^{th}, 7^{th} and 8^{th} grades in their peer-teaching experience in the methodology courses. In addition, the practicum courses in the 8^{th} semester allowed the teacher candidates to teach a real class under supervision and they were encouraged to integrate NOS into their lesson plans, objectives and practices. Thus, explaining NOS when teaching their subjects was not difficult for these teachers when they became practicing teachers after graduation. This point is supported by the classroom observation in the current study and in the interviews, for example; one teacher (T 4) commented:

> "… with respect to integrating NOS, if teachers are qualified related to NOS and teaching NOS, she/he can teach at least one of the NOS aspects in each unit (subject) of science course because teaching NOS aspects does not need a special learning environment in classroom."

When observed in the classroom, this teacher explained NOS aspects through an explicitly reflective approach. At the beginning of the lesson the teacher showed some pictures (such as young and old women) to engage students and asked what do you see in these pictures. Most of the students saw different things in the same pictures. Through discussion, the teacher ensured that the students reach the conclusion that scientists are influenced by their life experience and socio-cultural environment. Before investigating the structure of the atom, students made the black box activity. The teacher gave them a black box and asked them to imagine that they are holding the atom. The teacher asked what they thought about the inside of their black box. Students did not open the box and try to investigate the inside of the box. They recorded their observation, made inferences about the inside of the box and draw picture and discuss their drawings Through this activity students understood the distinction between observation and inference, and the idea that scientific knowledge is partly a product of human inference, imagination, and creativity. Furthermore, in explaining the history of the atom, the teacher allocated roles to students as scientists, then created an environment in which students can become aware of and discuss the tentative nature of scientific knowledge.

Our findings indicated that knowing how to teach NOS is an important factor for teachers transferring their knowledge and understanding of NOS to their classroom practices as well as teachers' NOS views and this is supported by the work of Abd-El-Khalick et al. (1998). In the current study, knowing how to teach NOS had a direct effect on teachers' classroom practices. Teachers who had informed NOS views and were informed about teaching NOS were able to integrate NOS explicitly-reflectively. However, the findings of Bell et al (2000) differed from those of the current study despite the fact that in their study the teachers had received education related to NOS and had been taught how to integrate into their future teaching the results from the study by Bell et al. (2000) showed that pre-service teachers were not able to transfer their NOS views to their classroom practices. The results of the interviews in the current study showed that T 6 and T 9 only integrated NOS explicitly and directly. The science and technology curriculum includes the objectives about NOS and teachers are aware that they should achieve these objectives. However, they only used verbal means to do this. Although the teachers have theoretical knowledge about NOS, they do not have enough knowledge about how to teach NOS. T 9 explained that her undergraduate studies did not include any courses on NOS and she was informed about NOS through her own post-graduate research and the scientific conferences she attended. T 6 stated that he took a theoretical course on NOS but during his undergraduate studies no courses were available on how to teach NOS. They commented further:

> "Although I have acquired some knowledge about some of the theories on NOS through the conferences I attended and research I have undertaken, I do not know for sure how to teach NOS in practice."

> "Now I realize that I did not have much awareness about NOS at my university. If I had a chance to go back, I would be willing to study in detail how to integrate each aspect of NOS with the subjects included in the lesson plans and to put it into practice. I do not think I am well-equipped about this subject. However, I believe that I can improve myself as I gain experience."

Mellado et al. (2007) supported our findings that most of the pre-service teachers had naive or transitional views of NOS. In Turkey, although the graduate education program has been developed in order to improve pre-service teachers' NOS views, there was little evidence of the expected improvement regarding their NOS views. In most of the studies it was found that there was no direct relationship between teachers NOS views and their classroom practices.

Teachers were observed to verbally explain the theoretical knowledge concerning NOS that they presented in related lessons with their classes. For example, T 9 said that she repeated that theories on atoms were not absolute whenever the topic arose. T 9 also explained to her students that some facts that were accepted when she was a student; such as "the smallest particle of an element is an atom" are no longer true. However, teachers may also convey wrong or inaccurate information and this can result in the students having misconceptions. For example:

"Also I am saying that scientific knowledge can be proved by evidence."

Although other teachers have well-informed views about some aspects of NOS, they do not have enough knowledge about NOS concepts and how to teach these concepts to the students. In addition, these teachers do not have enough knowledge about the terminology of NOS, the integration of NOS into the science and technology curriculum and NOS objectives that include the aspects to be taught to the students. This view is supported by Aslan and Tasar (2013). Chun (2000) also found that teachers are not familiar with the NOS terminology in the literature and are not sure about what they believe about the terms. In the current study several teachers stated that they did not have any undergraduate courses on NOS and felt inadequate about teaching NOS and although they had received in-service training on the implementation of the science and technology curriculum this was not sufficient. Therefore, when these teachers conduct student-centered activities, they think that the students are able to make the necessary deductions about NOS.

Assertion regarding Measurement of NOS

The interviewed teachers undertake a performance-based assessment approach less often due to having too many students in the class and the overloaded curriculum. In addition, the in-class observation showed that the teachers, except for T 4 and T 5, did not take into account the assessment of NOS in the learning process or the individual differences of the students. The teachers think that this subject matter is not required in the SBS therefore student learning in NOS does not need to be assessed. Furthermore, the teachers were not sufficiently qualified to know how to achieve or assess the NOS objectives. These findings showed similarities with the study of Aslan and Tasar (2013). Sandoval (2005) and Meichtry (1998) supported the process of project assignment and observing students during the process of the inquiry based activities in order to assess progress in acquiring knowledge of NOS.

> T 6: "The ideal method for measuring the NOS awareness of the students in crowded classes is to ask questions. However, in classes with fewer students, a better method might be to allow the students to learn by experiencing and living, and observe their performance."

> T 5: "When I give an assignment to the students in less-crowded classes, they achieve different and better results. Students particularly like using their imagination. I measure this process to evaluate their awareness of the students about NOS."

A review of the science and technology course books shows that they contain information about the historical development of concepts (for example, the atom). These books usually give the development of the theories in chronological order and at the end of the book there are some questions for the students to answer; such as: "Do you think information is limited to what is given here or is it possible to add new information over time?" The results of the observations showed that T 4 and T 5 used reflective questions to guide the students to answer this question. They also asked students different questions to encourage them to think and evaluate their awareness of NOS. The remaining 7 teachers asked the same question as in the book and gave the correct answer themselves after eliciting opinions from a few students.

Assertion regarding Integration of HOS

Teachers' views about perceptions and practices regarding HOS integration were all at an acceptable level, but their perceptive means were higher than that of their practices. All the teachers aimed to integrate HOS in their courses to improve students NOS understanding, especially the tentative aspects of NOS. In the literature most of the studies supported the idea that teaching HOS generally improves the understanding of NOS (Guney & Seker, 2012; Irwin, 2000; Seker, 2012; Seker & Welsh, 2006; Solomon et al., 1992; Wang & Cox-Petersen, 2002). King (1991) supported the idea that being familiar with HOS and NOS helped teachers in their instructional practices.

Contrary to the findings of Wang and Marsh (2002), the teachers in this study mostly explained conceptual understanding by integrating HOS in their courses and the least emphasis was given to contextual understanding. Teachers reported that they most explained the tentative nature of scientific knowledge through the HOS in the science courses. The findings of Wang and Marsh revealed that teachers mostly used HOS in their courses to promote students contextual understanding compared to other categories. Furthermore, in that study teachers did not integrate procedural understanding with their curriculum.

In the current study the teachers used HOS in their science classes through different teaching methods for different purposes as found by Wang and Cox-Petersen (2002). Teachers gave importance to HOS activities if it was related to the curriculum, such as the history of the atom in the science and technology course book. Most of the teachers used role playing methods to deal with the history of the atom as long as conditions existed such as time being available and having a smaller number of students in the class. Similarly, in the study by Wang and Cox-Petersen it was found that teachers believed their curriculum was overloaded with topics. Therefore, they did not give importance to HOS in their curriculum.

Assertion regarding Problems related to the Integration Process of NOS and HOS

In this process some possible problems might emerge such as creating misconceptions, not explaining the NOS aspects effectively, the students' beliefs and individual differences, and the classroom environment and these might negatively affect the teachers' integration of NOS and HOS.

Insufficient explanations in textbooks, teachers' and students' inadequate knowledge of the language of NOS, or students' previous misconceptions were reported as the factors which resulted in students misunderstanding NOS. In the supporting literature, similar comments were made showing that teacher language in science instruction, the instructional materials used, (such as some deficiencies found in the textbooks) can affect student views of the NOS understandings (Meichtry, 1993). This is also supported by Irez (2009) who gave the example of biology textbooks that included incorrect concepts which might influence teachers' views regarding NOS. Namely, while theories and hypotheses are tentative, laws are certain and not subject to change.

Limited time, lack of materials, overloaded curriculum, and inadequate knowledge of teachers meant that teachers were not able to explain all the aspects of NOS as they would have liked. Parallel to our findings in the literature it was found that the teaching approach used by teachers, their behaviors and explanations in the classrooms, teachers' naïve views and lack of knowledge regarding NOS, insufficient understanding of curriculum requirements can affect student understanding of NOS (Brickhouse, 1990; Clough, 1997; Dogan & Abd-El-Khalick, 2008; Duschl & Wright, 1989; Eichinger, Abell, & Dagher, 1997; Lederman & Zeidler, 1987). Findings of the Hacieminoglu, Ertepinar et al. (2012) revealed that even if teachers want to integrate HOS in science courses, they could not achieve their aims because of the overloaded curriculum and a negative classroom climate including the physical conditions and inadequate materials.

Teachers with high efficacy and motivation about teaching NOS were not able to give importance and sufficient time to integrate NOS in all the subjects because of the expectations of parents and school administrations regarding SBS. These results were supported by the studies conducted by Aslan and Tasar (2013) and Irez (2006).

Other problems reported by the teachers are related to students' individual differences such as students' belief, learning approach, and classroom environment. In Turkey, the national curriculum might force some students who are not interested in science but have to take the subjects, learn through memorization. Tobin and McRobbie (1997) stated that how students learn and how teachers supply the authority in class are the most important factors influencing the teachers' implementation of curriculum in a classroom. Student understanding of the NOS concepts may be influenced by not only teacher understanding and behaviors but also other classroom factors such as teacher characteristics and attitudes, student characteristics, and the classroom atmosphere, as indicated in the studies reported by Lederman and Druger (1985) and Lederman (1986).

Suggestions and Recommendations

The facilities in public schools such as the physical conditions should be improved in order for teachers' to effectively implement the science and technology curriculum as suggested by Dogan (2010). The class environment should facilitate constructivist learning for the implementation of the curriculum that also supports constructivism. The class should have fewer students. This would allow more freedom of movement and facilitate greater communication between students, more time for discussions about the experiments and activities they wish to do, and there should be adequate access to the materials that they require. The existing content of the science and technology curriculum should be rationalized allowing students more time to understand, discuss and think about the topics. Teachers should be provided with sufficient training concerning the curriculum, and the quality of the in-service training should be increased. In addition, the SBS should be removed. Research should be conducted to find ways to increase the effectiveness of the national curriculum and the education system should be modified to take into consideration the individual differences and interests of the students.

While integrating NOS, teachers should be highly skilled and able to guide students with reflective questions, create an environment for discussion, and give a performance based project, as well as encourage each student to actively participate. Furthermore, teachers should give importance to selecting appropriate language to convey their message, avoid creating misconceptions, and allow freedom in classroom environment for the students to explain their ideas. In order to achieve these goals, as recommended in the literature (Akerson & Abd-El-Khalick, 2003; Akerson & Hanuscin, 2007) teachers need to attend a long term professional development program to improve their understanding about NOS and to learn effective ways of teaching NOS.

Finally, all the teachers in the current study had suggestions about improving science education. First, the content of the science laboratory course in graduate education should be revised according to the activities in the elementary curriculum. The duration of the teaching methodology course should be at least four semesters (instead of the existing two semesters). In the methodology, the university instructors should give more feedback concerning students' lesson plans and proposed integration of NOS in these method courses. In the undergraduate teacher training, the NOS course and methodology courses should be highly experienced in teaching NOS in schools and very knowledgeable. For the practicum courses a high level of communication should be facilitated between the pre-service teachers and practicum supervisors about integration of NOS.

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