Pre-service Science Teachers' Beliefs about Science Teaching and Perception of the Nature of Science

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Abstract

For the successful implementation of educational reforms that aim to get students to be active learners, it has to be realized that teachers are the actual determiners of the classroom curriculum. Therefore, teachers who are in the position of the administrators of these reforms should get support and develop positive beliefs about the implementation of these reforms. The aim of the current research was to determine relationship between pre-service science teachers' beliefs about teaching science and their perceptions of the nature of science. This research focused on 37 senior students in the Department of Elementary Science Education. "Teacher Belief Interview", (Luft & Roehrig, 2007) and Views of Nature of Science Questionnaire (Lederman et al., 2002) were used. Results from the questionnaires and the interview were used to construct individual teacher's profiles. The profiles were used to identify relationships between their beliefs and perception of nature of science. Additionally, a positive significant correlation between two entities was found.

Key words: educational reforms, teacher beliefs, nature of science, science education

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Introduction

With developing technologies and proliferating information, the need for science literate individuals has been steadily increasing (Bybee & Fuchs, 2006). Science literate individuals are life-long learners who can develop inquiry, critical thinking, problem solving and decision-making skills. They also have the science-related skills, attitudes, values, conceptions and knowledge required to maintain their curiosity about their environment and the world (Ministry of National Education [Turkey], 2004). Individuals should be aware of the nature of science, how to acquire scientific information and the relationship between science, society and technology in order to be science literate (American Association for the Advancement of Science [AAAS], 1993; National Research Council [NRC], 1996). Many educational reforms based on constructivist approach, that can play an effective role in training of science literate individuals have been made. Teachers are critical for the successful implementation of such reforms as they are responsible for putting it into practice and, therefore, they should be supported to develop positive beliefs about constructivist learning and scientific literacy (Wallace & Kang, 2004; Chai, 2010). There can be some obstacles in front of the implementation of these reforms. Teachers occupying a key position for the implementation of these reforms within the education system need to adopt these reforms, develop mindsets necessary to follow and implement the reforms in their classroom because the actual determiners of the classroom curriculum are teachers. Therefore, their instructional beliefs are

of great importance in the formation of a classroom environment in which students can understand how scientists make sense of phenomenon taking place in daily life (Pomeroy, 1993; Roth et al., 1998).

Luft and Roehrig (2007) emphasize that teachers' beliefs about teaching have aroused a great deal of interest in educational research. Research has revealed that one of the most important factors affecting in-class practices of teachers is their beliefs (Nespor, 1987; Pajares, 1992; Wallace & Kang, 2004). Beliefs serve the function of a filter in the determination of which methods should be used to teach which topics in classroom and how these methods should be implemented (Pajares, 1992; Tanase & Wang, 2010). Determination of teachers' beliefs can contribute to the understanding their decisions made in educational settings, their patterns of classroom management, their assessment methods and events taking place in the classroom environment (Pajares, 1992; Richardson, 1996). Teachers informed about nature of science, adopting educational reforms and having beliefs in alignment with these reforms are expected to play the key role in the education of individuals who must be competitive, innovative and creative and have problem solving skills required by the modern age. The purpose of this study was to determine the relationship between the pre-service science teachers' perceptions of the nature of science and their educational beliefs. To this end, the following research questions were formed.

- What kind of beliefs do the pre-service science teachers have about science education?
- What is the pre-service science teachers' perception of nature of science?
- Is there a relationship between the pre-service science teachers' perception of nature of science and their beliefs about science education?

Belief Structure and Nature of Science

While Brown and Cooney (1982) define belief as a determining factor of actions and behaviors, Pajares (1992) defines it as an individual's deciding whether something is right or wrong on the basis of actions he intended to do or actually performed. Thus, while performing an action, decisions are made on the basis of beliefs. Therefore, classroom applications of teachers are considered to be reflections of their beliefs. The educational reforms have to be carried out not only in primary and elementary education but also in higher education because they have to give the teacher candidates opportunities to adopt a student-centered teaching approach such as constructivism. Pajares (1992) argues that teachers' experiences, they undergo as students affect teachers' beliefs and attitudes towards education and instruction. Therefore, if teachers are provided with opportunities to gain information and experience about new approaches throughout their school lives, they will more likely develop positive attitudes and beliefs about education-instruction (Guven & Crawford, 2004) and they will be supportive of new reform movements. In this regard, pre-service teachers' developing positive beliefs can make important contributions to the realization of reforms. Moreover, teachers make decisions about their classroom practices according to their beliefs (Brown, 2004; Chan & Elliott, 2004) and these beliefs also affect which methods they will use to teach subjects (Pajares 1992; Richardson 1996).

One of the objectives of the educational reforms is to create science literate individuals who can understand the nature and process of science and acquire scientific knowledge as a scientist. Therefore, teachers need to have a clear understanding about nature of science to train students as science literate individuals (Akerson, Buzzelli & Donnelly, 2008). Researchers (Abd-el-Khalick, Bell & Lederman, 1998, Akerson et al., 2006) have classified nature of science under seven dimensions. These are tentative nature of scientific knowledge, empirical nature of science, subjectivity in science and the structure of scientific knowledge, creative

nature of scientific knowledge, scientific method, structure of scientific theory and law, theoretical assumptions in science, nature of observation and inference, and relationship of science with socio-cultural elements.

Method

This correlational study employed mixed-methodology (Tashakkori & Teddlie, 1998). While qualitative research method was used for the in-depth evaluation of the science teachers' beliefs and understanding of nature of science, quantitative research method was used to explore the relationship between them. Data collected from qualitative questionnaire have been categorized as reform based and traditional beliefs. The participants of the study were 37 senior science teacher candidates in Education Faculty of Kırıkkale University, in Anatolian Turkey in 2013 spring semester who volunteered to participate.

Data Collection Instruments

In the current study, the Teacher Belief Interview developed by Luft and Roehrig (2007) was administered. It consists of seven open-ended questions. The translation of the questions into Turkish was performed by two language specialists and a subject-area expert. Moreover, the adapted instrument was tested with eight (8) teacher candidates in order to determine any items that might be misunderstood. The purpose of the interview was to elicit teachers' beliefs about classroom management in science teaching, student-teacher roles and interaction and classroom climate.

Another data collection instrument employed in the current study was the Views of Nature of Science Questionnaire (VNOS) developed by Lederman et al. (2002) in order to determine the opinions about nature of science. VNOS-C questionnaire includes 10 open-ended questions. In line with the responses given to the questions, their perceptions of NOS can be elicited.

Data Analysis

Two researchers independently coded all of the pre-service teachers' responses to the Teacher Belief Interview and constructed the themes. They categorized the codes in each theme as traditional and reform-based. The inter-rater reliability was found to be 0.89. The conflicts in categorization were discussed until reaching an agreement. The pre-service teachers' responses to the nature of science questionnaire were coded under the categories of naive, acceptable and realistic. Expressions complying with nature of science literature were accepted to be "realistic". The expressions that could not exactly reflect the characteristics of nature of science but partially or deficiently reflect these characteristics were coded as "acceptable". The responses considered "naive" include expressions and conceptual fallacies not complying with the characteristics of nature of science. Two researchers conducted the analysis of the responses of VNOS-C. In order to find the reliability of the comparative correspondence between the two researchers, Cohen Kappa coefficient was calculated as 0.81. Moreover, in order to conduct a statistical analysis between the teachers' beliefs and perception of nature of science, belief categories were turned into points as traditional: 0 and reform based: 1 points. In this way, the teachers' belief scores can vary between 0 and 6. In order to determine the teachers' general belief profiles, mean score intervals were used. Those having a mean score ranging from 0-3.0 were considered to have traditional beliefs, and those having a mean score between 3.1 and 6.0 were considered to have reform based beliefs. Also, biserial correlation coefficient was calculated in order to see whether there is a significant correlation between the teacher candidates' scores of beliefs and perception of nature of science.

Findings

Teacher Candidates' Beliefs about Science Teaching

The themes firstly were interpreted over the codes through direct references to the participants' statements. The themes and their related questions are given in Table 1. These themes represent the opinions about classroom role of the teacher, how teacher determines the curriculum and content, process of transition to a new topic, teacher and student roles in learning of science and signs of learning.

Table 1: Themes and questions related to the pre-service teachers' instructional beliefs.

Themes	Questions
Teacher	How do you describe your role as a teacher?
Determination of content	In the school setting, how do you decide what to teach and what not to teach?
Process of transition to a new topic	How do you decide when to move on to a new topic in your classroom?
Roles in effective learning of science	How do you maximize student learning in your classroom? How do your students learn science best?
Signs of learning	How do you know when your students understand? How do you know when learning is occurring in your classroom?

When the responses given to the question "*How do you describe your role as a teacher?* Were examined, 28teachers defined it in reform-based perception language as providing guidance for students to reach information rather than conveying discrete bits of knowledge to students (Table 2). Some students' excerpts in this regard are as follows:

> "*The teacher should show the route to be followed. He/she must help find the information rather than convey it*" (T19),
>
> "*As a teacher, my most important role should be to provide guidance to my students. I must do my best in showing them the ways while they are trying to have access to information*" (T13),
>
> *"I cannot know everything, as a teacher, the things that I can know are limited. However, I think I can help them to reach the details of information and its sources and I can motivate them to do this. (T1)"*.

Table 2: Themes and codes about role of the teacher

Themes	Belief Categories	Codes	Number of Teachers
Teacher	Reform-based	Guidance Helper Preparing for life	28
	Traditional	Controlling Lecturing Source of information Using the board well	9

On the other hand, nine of the pre-service teachers think that the teacher's role in the class is to convey information to students as can be seen in their following statements;

> *"The teacher should be adept at using the board; he can make the lesson enjoyable by telling stories so that students can understand the topic well. Effective instruction naturally leads to success of students."* (T34)

> *"The teacher is the person who holds the control of the class and demonstrates the maximum performance for students to learn" (T5)*.

A majority of the participants stated that the role of teacher must be guidance, reflecting a student-centered learning approach; few of the participants emphasized the teacher's traditional roles such as conveying information and controlling the classroom.

The most commonly given response to the question "*In the school setting, how do you decide what to teach and what not to teach?"* is the readiness level of students (table 3). Almost half of the participants (17 teachers) seem to have adopted a student-centered approach that considers students' interests, wishes, needs and readiness levels and some of the students' excerpts in this regard are as follows:

> *"By considering students' readiness levels, interests, wishes and needs. I attach the main priority to the determination of the topic through which I can teach them how and where to find information by means of inquiry."* (T13)

> *"Collecting information about students' prior information and readiness levels helps me to decide what to do"* (T19).

On the other hand, 20 teacher candidates demonstrate a traditional attitude by stating that they make decisions about what to teach or not to teach according to the curriculum, teacher manual and what they are good at. Some excerpts in this regard are as follows;

> *"I think that I cannot demonstrate effective teaching performance in relation to subject areas about which I do not have enough knowledge, experience and creativity" (T15),*

> *"I make my decisions by considering the curriculum and developmental level of students" (T7)*.

Table 3: Themes and codes related to determination of the course content

Themes	Belief Categories	Codes	Number of Teachers
Determination of the course content	Reform-based	Students' readiness levels Students' interests, needs and wishes	17
	Traditional	Curriculum Teacher's manual and objectives Topics about which the teacher feels competent	20

In relation to the process of transitioning to a new topic, most of the pre-service teachers expressed their opinions within the framework of the traditional approach by considering the exam, curriculum, time and concluding the unit (Table 4). Some students' excerpts in this regards are as follows;

> *"After the topic has been taught, I start a new topic" (T7),*

"After I have concluded that students have learned enough, I decide to go on with a new topic considering the order of the topics in the curriculum" (T15);

"I go on with a new topic when students can easily answer my questions"(T14).

Table 4: Themes and codes about related to process of transition to a new topic

Themes	Belief Categories	Codes	Number of Teachers
Process of transition to a new topic	Reform-based	Question-answer technique Not grade-oriented assessment	10
	Traditional	Exam results Time Concluding unit (curriculum) Opinion that students have understood	27

On the other hand, only ten (10) participants stated that they would adopt a student-centered approach in this regard.

"First, diagnosis tests are conducted. As a result of these tests, some remedial activities are given to students who are thought to have some missing information and meanwhile additional enhancement activities are provided for students who are thought to have learned the topic and then teaching of a new unit is initiated after checking the learning of all students." (T35),

"I discuss the topic with my students; thus, I try to decide whether they have understood the topic or not. It is followed by an assessment to develop their creativity. However, I never carry out oral exam for this purpose. " (T16)

The issue most emphasized by the participants within the context of the theme of roles in learning of science is reform based. In response to the questions *"How do you maximize student learning in your classroom? How do your students learn science best?", while* 28 teacher candidate exhibited reform based beliefs, 9 of them stated traditional beliefs about teacher roles in learning of science (table 5). Some students' excerpts in this regard are as follows;

"*I believe that students can best learn science by means of conducting experiments in the laboratory because the best learning can be realized by activating five senses. The laboratory is a very suitable place to conduct activities catering to five senses." (T13)*

"I think they best learn through experiments. I never forget what I have learned through experiments." (T1)

"As science is deeply ingrained in life, students need to conduct experiments to learn by experiencing and doing." (T22)

They also pointed out that for effective science learning, various teaching techniques should be used in class, materials addressing different senses should be provided and activities that can motivate students and arouse their curiosity and interests should be included. Some students' excerpts in this regard are as follows;

"We need to address both the ear and the eye of children and we do not bore them so that they can pay the greatest attention to the lesson. Advanced equipment should be provided for teachers (projector)" (T30)

"I pay great attention to make the lesson enjoyable for students. I use materials activating more senses in the class" (T3),

"I try to use teaching materials suitable for students' level and needs, I start my teaching with an interesting introduction and by using accurate materials, I try to make students active in the class"(T4),
"By using different methods and techniques as much as possible, relating their learning to real life and preparing scenarios from daily life for students, the level of learning can be enhanced"(T21),
"I can make students to achieve high level of learning by considering their individual differences and applying suitable methods and techniques."(T9).

Table 5: Themes and codes about related to roles in effective learning of science

Themes	Belief Categories	Codes	Number of Teachers
Roles in effective learning of science	Teacher in reform based instruction	Using methods suitable for students' levels and needs Considering individual differences Relating to the daily life Providing materials activating five senses	28
	Teacher in traditional instruction	Getting students to conduct experiments Using different teaching techniques Motivating, drawing interest, arousing curiosity	9
	Students in reform based instruction	Active participation in class Use of information in daily life Use of science process skill	31
	Students in traditional instruction	Answering questions Listening teacher carefully	6

Another strongly emphasized issue within the theme of student roles in effective learning of science is students' active participation in lesson. Some students' opinions in this regard are as follows;

"I enable students to actively participate in the process and thus, to learn by doing and experiencing (T18);
The more active students are in lesson and the more interaction takes place in lesson, the more students learn (T4)."

From the students' responses to the questions *"How do you know when your students understand? How do you know when learning is occurring in your classroom?"*, it was concluded that they make their decisions related to whether learning has occurred or not based on "Measurement and assessment results", "Comprehension level of information", "Behavioral responses" and "Affective expressions" (table 6). 12 of the participants stated that they could decide whether learning had occurred by considering students' performance to relate the information to daily life, to make original inferences and to restate the information by using their own expressions, and their perceptions show that they have adopted an innovative attitude. Some students' excerpts in this regard are as follows;

"*If students can express the topic with their own words, develop different approaches to the solution of a related problem and present new and different examples, then this means that they have learned."(T17),*

"If they can relate to the topic to their own live, for instance, while they are climbing a hill, they have to should able to ask themselves that whether they experience difficulty in breathing or not (T16).

On the other hand, many of the pre-service teachers stated that they could decide whether learning had occurred by using measurement-assessment tools such as exam results, experiment reports, assignments and questions asked during the lesson. Some opinions stated in this respect are as follows;

"I understand from whether they give correct answers to questions"(T31),

"After teaching the topic, I ask open-ended questions and on the basis of students' responses to these questions, I can determine whether they have learned or not."(T3),

"Whether learning has occurred or not is determined through a measurement and assessment scale carefully administered by the teacher. The exams may not exactly determine whether learning has occurred but they offer some insights to the teacher. Students working and not working should be distinguished."(T14).

Some pre-service teachers stated that they could understand whether students had learned or not from their facial expressions and looks.

"Eye contact, their looks and interest in lesson help us to understand this."(T35),
"From their facial expressions while responding to questions"(T30).

Table 6: Themes and codes about related to the theme of signs of learning

	Belief Categories	Sub-Themes	Codes	Number of Teachers
Signs of learning	Reform based	Comprehension level of information	Transfer of information to daily life Interdisciplinary lesson Original questions and answers Making original inferences and sharing Patterns of self-expression	12
	Traditional	Summative assessment	Transfer of information to daily life Interdisciplinary lesson Original questions and answers Making original inferences and sharing Patterns of self-expression	25
		Behavioral responses	Classroom behaviors Eyes-Looks Facial expressions Being quiet	
		Affective statements	Willingness to answer Loving the teacher Asking questions without fear	

Perception of the Nature of Science

Besides their beliefs about teaching, another important element affecting teachers' classroom practices is their conception of nature of science. Laplante (1997) stated that

teachers' conception of nature of science partially determines whether they include teacher-centered or student-centered applications in their classes. The pre-service teachers' conceptions of nature of science were analyzed under three categories: being naïve, acceptable and realistic. While more than half of the pre-service teachers hold realistic opinions about the empirical nature of science, creative nature of scientific knowledge and the relationship of science with socio-cultural elements, they have naïve conceptions of the relationship between the structures of scientific theory and law (Table 7).

Table 7. Pre-service Teachers' Conceptions of Nature of Science (n=37)

Dimensions of Nature of Science	**Naïve**	**Acceptable**	**Realistic**
Tentative nature of scientific knowledge	10	14	13
Empirical nature of science	1	15	21
Subjectivity in science	7	13	17
Creative nature of scientific knowledge	1	10	26
Scientific method	11	19	7
Structure of scientific theory and law	18	15	4
Nature of observation and inference	8	13	16
Social and cultural embeddedness of science	4	13	20

Fourteen (14) pre-service teachers have realistic opinions about "Tentative nature of scientific knowledge". As this dimension is in an interaction with misconception of the relationship between the theory and law, it can be argued that the students' responses are far from being realistic. Some students' opinions in this connection are as follows;

> *"Until a new atom theory or a new model is adopted, scientists' opinions about atom will be correct or acceptable. Some of them likened atom to raisin pie, some others likened it to different models and reached some certain conclusions and found their own truth (T2),*
>
> *I do not think opinions about the structure of atom are certain. While it was maintained that atom could not be disintegrated in former times, now nuclear energy is generated by disintegrating atom" (T12)*.

A Majority of the pre-service teachers (22) have realistic opinions about "the empirical nature of science". In their opinions, natural sciences differ from other scientific disciplines in terms of being empirical, and scientific information can be obtained not only by means of experiments but also through observations and interpretations of new information. Thirty three percent of the pre-service teachers maintained that for the collection and confirmation of scientific information experiments are necessary. The pre-service teachers also pointed out that creative individuals make use of their imagination and creativity from the identification of the problem to its solution. One candidate stated

> *"The scientist wonders; he/she is imaginative. He/she wonders how something happens; how he/she can do. His/her creativity plays an important role in the identification and solution of a problem."(T17)*.

However, a high majority of the pre-service teachers (22) could not explain the difference between the theory and law of science. They think that there is a hierarchy between these two scientific terms. Some of the students' excerpts in this regard are as follows;

"While the theory has not been proved yet, the law has been proved. Theories change buy laws do not (T36).

"Scientifically, theory cannot be considered to be certain. It can be refuted, changed; it has not been certainly proved yet. For instance, the evolution theory is just a theory and there is no certain proof of it. Law, on the other hand, includes more certain results. Newton Laws is a law" (T9),

"A theory can be refuted but a law cannot (T19).

Nearly half of the participants (44%) were found to have realistic opinions about the differences between observation and inference. For instance, a participant expressed her opinions in this regard as follows

"In the classification of living things, the concept of species goes back to very old times. The concept of species is well-established. As a result of mating of a horse and a donkey, a birth is given to a mule. The mule is not fertile" (T20).

Nearly half of the pre-service teachers have realistic opinions about the relationship of science with socio-cultural elements. By means of statements such as

"Science is affected from social and cultural values like not talking about that the world is round as it will be problematic from religious and social viewpoints or not supporting research related to cloning due to some religious attitudes" (T23),

"Different outcomes will affect how information is interpreted on the basis of past knowledge and experiences. Thus, different conclusions can be reached from different viewpoints" (T36).

They emphasized that interpretation of the collected data is affected by the socio-economic environment, religious beliefs and previous experiences.

Relationship between teachers' beliefs about science teaching and perception of the nature of science

Pre-service teachers have different beliefs in different topics. In other words, beliefs may not be consistent from topic to topic (Luft & Roehrig, 2007; Ogan-Bekiroğlu & Akkoç, 2009). Some pre-service teachers may have reform-based beliefs about the teacher role while having traditional beliefs about determination of the course content. When scored teacher beliefs categories, twenty three of them have traditional beliefs while the rest of them have reform-based beliefs.

The pre-service teachers' belief categories and VNOS-C scores are given in Table 8. Biserial correlation coefficient was calculated in order to see whether there is a significant correlation between the teachers' scores. A biserial correlation is used to measure the strength and direction of the association that exist between one continuous variable, VNOS score, and one artificially dichotomous variable, teacher belief categories (Howell, 2012). It was found that there was a statistically significant correlation between these scores (r_b=0.62, p=0.05, n=37). This coefficient indicates that there is a positive correlation between the pre-service teachers' beliefs about learning and their perception of nature of science. More specifically, the data of the teacher candidates show that those with having reform-based teaching beliefs tended to have higher VNOS-C scores than the others.

Table 8: VNOS-C Scores according to teaching beliefs categorized as traditional and reform-based

VNOS-C scores of the pre-service teachers having traditional teaching beliefs(n:23)		VNOS-C scores of pre-service teachers having reform-based teaching beliefs(n:14)
12	18	16
13	18	17
13	18	17
13	18	18
14	19	19
14	20	19
14	21	20
15	21	20
15	21	21
16		21
16		21
16		22
17		22
18		23

Discussion

The pre-service teachers have only reform based beliefs about the role of teacher and teaching owning to a result of the experiences gained during their undergraduate education. They might develop awareness of new teaching methods in which teacher considers students' readiness levels and different methods during the teaching process in that time. However, as the pre-service teachers do not have enough professional experience, they have traditional beliefs in terms of the determination of whether learning occurs and of curriculum-content area. Laplante (1997) argued that teacher-centered approach could be more likely followed during their classroom applications by teachers seeing themselves as the source of information and viewing science as an accumulation of information. Hashweh (1996) stressed that teachers adopting the constructivist approach mostly follow a teaching program by determining the readiness levels of their students for meaningful learning to take place. The study shows that teachers' beliefs play an important role in the determination of the curriculum.

The pre-service teachers have realistic conceptions of the empirical nature of science, creative nature of scientific knowledge and the relationship of science with socio-cultural structure. Having realistic opinions about these concepts and suggestion of different theories about the structure of atom as a result of developing technologies might have influenced their conception of the tentative nature of scientific knowledge. The pre-service teachers have inadequate information about the subjectivity of science and the difference between the theory and the law. Because of the educational reforms realized in 2004, references to nature of science have been given in textbooks. Unfortunately, up to that time, there used to be information presented in textbooks not complying with nature of science (Akgul, 2006; Celik & Bayrakceken, 2006; Tasar, 2006). Therefore, many teachers have conceptual fallacies and erroneous information. Moreover, as the concept of law has been used to represent something not susceptible to change and the concept of theory has been used with the same meaning as hypothesis in daily life, conceptual fallacies deeply rooted in the minds of students.

The current study sought the relationship between pre-service teachers' beliefs about teaching and learning and perception of nature of science. Statistically significant correlation was found. The result underlined pre-teachers who have traditional beliefs are more likely to have naïve understanding about NOS while the others having reform-based beliefs tend to have realistic perception of nature of science. They are most likely to become traditional teachers when being in service teacher because teaching experience in university has a critical role in the creation of a classroom environment (Pomeroy, 1993; Roth et al., 1998). The study conducted by Tsai (2002) pointed out that while in service teachers having strong conceptions of nature of science involve student-centered activities in their classroom applications, teachers having weak conceptions of nature of science mostly concentrate on teacher-centered activities. Moreover, Kim and Yoon (2013) stated that teacher beliefs about NOS, learning and teaching closely aligned. According to another research, teachers' perceptions about nature of science are a determining factor in their choices for instructional strategies (Water-Adams, 2006; Kang, 2008). Laplante (1997) reported that whether teachers incorporate teacher-centered or student-centered applications into their classroom practices affect their perceptions of nature of science. In another study, Byran (2012) stressed that teachers' attitudes towards the understanding of nature of science and how students learn science reflect their beliefs guiding their classroom applications and behaviors. Özdemir (2007) studied how teachers' conceptions of nature of science affect their classroom applications. He stated that teachers emphasizing that science is objective and repeatable by focusing on scientific result/product rather than scientific process adopt more teacher-centered applications, make more use of traditional assessment tools but they do not attach the necessary importance to the teaching of scientific theory. However, significant correlation between teacher' beliefs about NOS and constructivist teaching was found in a recent study (Yoon & Kim, 2016).

For reform-based applications to fulfill the objectives in education system, first, teachers' awareness of their inner beliefs should be raised because they reconstruct the revised curriculum in classroom according to their teaching beliefs. Thus, teachers are critical for the successful implementation of educational reform. Therefore, teachers have to be encouraged to gain reform-based teaching beliefs to reach educational reform aims. In addition, teacher-training programs should consider pre-service teachers' beliefs and the ways to shape these beliefs.

Future research may collect more detailed data by analyzing the classroom applications of pre-service teachers and their lesson plans and thus determine the extent to which emphasis is put on nature of science and which teaching approaches are adopted by them.

References

AAAS. (1993). Benchmarks for Science Literacy. Oxford University Press. New York.

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

Akerson, V.L., Buzzelli, C.A., & Donnelly, L.A. (2008). Early childhood teachers' views of nature of science: The influence of intellectual levels, cultural values, and explicit reflective teaching. *Journal of Research in Science Teaching,* 45, 748–770.

Akerson, V. L., Morrison, J. A. & McDuffie, R. A. (2006). One course in not enough: Preservice teachers' retention of improved views of nature of science. *Journal of Research in Science Teaching*, 43, 194-213.

Akgul, E. (2006). Teaching science in an inquiry-based learning environment: what it means for pre-service elementary science teachers. *Eurasia Journal of Mathematics, Science and Technology Education*, 2(1). 71-81.

Brown, C. A., & Cooney, T. J. (1982). Research on teacher education: A philosophical orientation. *Journal of Research and Development in Education*, 15(4), 13-18.

Brown, E. (2004). What precipitates change in cultural diversity awareness during a multicultural course: The message or the method? *Journal of Teacher Education,* 55, 325-340.

Bryan, L. A. (2012). Research on science teacher beliefs. In B. Fraser et al. (Eds.), *Second International Handbook of Science Education* (pp. 477–495). Springer International.

Bybee, R.W., & Fuchs, B. (2006). Preparing the 21st century workforce: A new reform in science and
technology education. Journal of Research in Science Teaching, 43, 349-352.

Celik, S. & Bayrakceken, S. (2006). The Effect of a Science, Technology and Society Course on Prospective Teachers' Conceptions of the Nature of Science. *Research in Science and Technological Education*, 24(2), 255-27.

Chai, C.S. (2010). Teachers' epistemic beliefs and their pedagogical beliefs: A qualitative case study among Singaporean teachers in the context of ICT- supported reforms. TOJET: The Turkish Online Journal of Educational Technology, 9(4), 128-139.

Chan, K. W. & Elliott, R. G. (2004). Relational analysis of personal epistemology and conceptions about teaching and learning. *Teaching and Teacher Education*, 20, 817-831.

Guven, D., & Crawford, B.A. (2004). Prospective science teachers' ideas of inquiry and the laboratory in the context of practice. A paper presented at the 2004 Annual International Conference of the Association for the Education of Teachers in Science (AETS), Nashville, TN, January 7–11, 2004.

Hashweh, M.Z. (1996). Effects of science teachers' epistemological beliefs in teaching. *Journal of Research in Science Teaching*, 33, 47-63.

Howell, D.C. (2012) Statistical methods for psychology (8th Ed.) Australia: Wadsworth, Cengage Learning.

Kang, N-H. (2008). Learning to teach science: Personal epistemologies, teaching goals, and practices of teaching. *Teaching and Teacher Education, 24*(2), 378–405. doi: 10.1016/j.tate.2007.01.002

Kim, J-I., & Yoon, H.-G. (2013). Elementary school teachers' beliefs about science teaching, science learning and the nature of science. *Journal of Science Education, 37*(2), 389-404.

Laplante, B. (1997). Teachers' beliefs and instructional strategies in science: Pushing analysis further. *Science Education, 81*(3), 277–294.

Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of the nature of science questionnaire: Toward valid and meaningful assessment of learners' conceptions of the nature of science. *Journal of Research in Science Teaching*, *39*(6), 916-929.

Luft, J. & Roehrig, G. (2007). Capturing science teacher's epistemological beliefs: The development of the teacher beliefs interview. *Electronic Journal of Science Education, 11*(2), http://ejse.southwestern.edu/volumes/v11n2/articles/art03_luft.pdf

Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies, 19*, 317–328.

Ministry of National Education (2004). Fen ve teknoloji dersi programı, ilköğretim 4.–5. sınıf. Ankara.

NRC (National Research Council). 1996. National Science Education Standards. National Academy Press. Washington D.C. http://stills.nap.edu/readingroom/books/nses/html/

Ogan-Bekiroglu, F., & Akkoc, H. (2009). Pre-service teachers' instructional beliefs and examination of consistency between beliefs and practices. *International Journal of Science and Mathematics Education, 7*, 1173-1199.

Özdemir, G. (2007). The effects of the nature of science beliefs on science teaching and learning. *Uludağ Üniversitesi Eğitim Fakültesi Dergisi*, *20*(2), 355-372.

Pajares, M.F. (1992). Teachers beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*, 307–332.

Pomeroy, D. (1993). Implications of teachers' beliefs about the nature of science: Comparison of the beliefs of scientists, secondary science teachers, and elementary teachers. *Science Education, 77*, 261–278.

Richardson, V. (1996). The role of attitudes and beliefs in learning to teach. In J. Sikula (Ed.), Handbook of research on teacher education (pp. 102–119). New York: Macmillan

Roth, W.M., McGinn, M.K., & Bowen, G.M. (1998). How prepared are pre-service teachers to teach scientific inquiry? Levels of performance in scientific representation practices. *Journal of Science Teacher Education, 9*, 25–48.

Tanase, M., & Wang, J. (2010). Initial epistemological beliefs transformation in one teacher education classroom: Case study of four pre-service teachers. *Teaching and Teacher Education, 26*, 1238-1248.

Tsai, C. C. (2002). Nested epistemologies: science teachers' beliefs of teaching, learning and science. *International journal of science education, 24*(8), 771-783.

Tasar, M.F. (2006). Probing Pre-service Teachers' Understandings of Scientific Knowledge by Using a Vignette in Conjunction with a Paper and Pencil Test. *Eurasia Journal of Mathematics, Science and Technology Education, 2*(1), 53- 70.

Tashakkori, A., & Teddlie, C. (1998). Mixed methodology: Combining qualitative and quantitative approaches. Thousand Oaks, CA: Sage.

Wallace, C., & Kang, N. (2004). An investigation of experienced secondary science teachers' beliefs about inquiry: An examination of competing belief sets. *Journal of Research in Science Teaching, 41*, 936–960.

Waters-Adams, S. (2006). The relationship between understanding of the nature of science and practice: The influence of teachers' beliefs about education, teaching and learning. *International Journal of Science Education, 28*(8), 919-944.

Yoon, H-G. & Kim, B. S. (2016). Pre-service Elementary Teachers' Beliefs about Nature of Science and constructivist teaching in the content-specific context. *Eurasia Journal of Mathematics, Science & Technology Education, 12*(3), 457-475.