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Investigation of the Relationship between Pre-service Science Teachers' Epistemological Beliefs and Beliefs about Nature of Science

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The present study investigated the relationship between pre-service science teachers' epistemological beliefs and beliefs about nature of science. For this aim, Schommer's Epistemological Belief Questionnaire (SEQ) and Beliefs about Nature of Science Scale (BNOS) were conducted to 219 pre-service science teachers attending four public university in Turkey. For data analysis, SPSS program was used and correlation analysis was conducted to investigate the relationship between epistemological beliefs and beliefs about nature of science. Results showed that the more sophisticated epistemological beliefs pre-service science teachers have, the more informed beliefs about nature of science they have. Also it was found that positive/negative significant correlations among the four subscales of Schommer's Epistemological Belief Questionnaire and seven subscales of Beliefs about Nature of Science Scale. The implications were discussed.

Introduction

One of the most popular definition of epistemological beliefs was suggested by Hofer and Pintrich (1997) as "how individuals come to know, the theories and beliefs they have about knowing, and the manner in which such epistemological premises are part of and an influence on cognitive process of thinking and reasoning beliefs about the processes of knowing and the nature of knowledge" (p. 435). Hofer and Pintrich (1997) proposed that there are two general structure of epistemological beliefs. First one, personal epistemological belief, is beliefs about the nature of knowledge (i.e., including certainty of knowledge and simplicity of knowledge) while the second one, scientific epistemological belief, is beliefs about the nature or process of knowing (i.e., including source and justification of knowing).

Personal epistemological beliefs can be associated with a person's learning strategies (Chan, 2003; Çakır, 2008; Tsai, 2012). These beliefs can be influenced by education and a teacher's pedagogy (Brownlee & Berthelsen, 2008; King & Kitchener, 2004).

There are controversies regarding whether personal epistemological beliefs are domain-

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general or domain-specific. The initial studies on personal epistemological beliefs were studied with an implicit assumption that epistemological beliefs are domain-general (Muis, Bendixen, & Haerle, 2006; Schommer & Walker, 1995). In this approach, it was claimed that if individuals conceive of knowledge as certain and simple, they would believe this to be true for all domains like mathematics, physics, history, and so on. However, Estes, Chandler, Horvath and Backus (2003) suggested that the domain-generality of epistemological beliefs should be questioned and many other researchers accepted that epistemological beliefs can differ substantially across domains and they are domain-specific (Hofer, 2000; Paulsen & Wells, 1998; Stodolsky, Salk, & Glaessner, 1991; Tsai, 2006). There are some other studies proposing that epistemological beliefs are both domain-general and specific (Buehl & Alexander, 2001; Schommer-Aikins, 2002). Therefore, although Schommer's original domain-general epistemological belief questionnaire evaluates personal epistemology at a domain-general level, domain specific version of Schommer's epistemological belief questionnaire is employed to evaluate students' epistemological beliefs in the fields of mathematics, socials sciences, and business (Schommer-Aikins, Duell, & Barker, 2003). Hence, in this study, the domain-general version was used and instructed pre-service science teachers to keep science in their mind as a domain-specific. In this way, domain-general version was used as if it is domain-specific version. Therefore, both epistemological beliefs and nature of science were considered as a domain specific.

Schommer (1990) suggests that personal epistemology is a belief system consisting of more or less independent dimensions and stated that epistemological beliefs affect the students' processing of information and monitoring of their comprehension. Schommer developed a theoretical framework concerning epistemological belief system:

(1) Personal epistemology may be conceptualized as a system of beliefs that is personal epistemology is composed of more than one belief.
(2) Beliefs within the system are more or less independent, that is, it cannot be assumed that beliefs will be maturing in synchrony.
(3) Epistemological beliefs are better characterized as frequency distributions rather than dichotomies or continuums.
(4) Epistemological beliefs have both indirect and direct effects.
(5) Whether epistemological beliefs are domain-general or domain-specific will vary over time for any particular individual.
(6) Epistemological belief development and change is influenced by experience. These experiences include engaging in problem solving and learning from family, friends, formal education, and life experiences (Schommer-Aikins, 2002, p. 106).

Schommer identified five dimensions which are source of knowledge (Omniscient Authority), certainty of knowledge (Certain Knowledge), organization of knowledge (Simple Knowledge), control of learning (Innate Ability), and speed of learning (Quick Learning). Schommer (1990) developed a 63 Likert-type item questionnaire named The Schommer Epistemological Questionnaire (SEQ) and identified five dimensions. Table 1 indicates these epistemological dimensions.

Table 1. Schommer's (1990) hypothesized epistemological dimensions.

Epistemological Beliefs	Definition
Simple Knowledge	Knowledge is simple rather than complex.
Omniscient Authority	Knowledge is handed down by authority rather than from reason and empirical evidence.
Certain Knowledge	Knowledge is unchanging rather than tentative.

Quick Learning	Learning is quick or not at all.
Innate Ability	The ability to learn is innate rather than acquired.

Schommer (1990) stated that personal epistemology is multidimensional and students' beliefs towards knowledge are related with five basic dimensions:

(1) "Source of knowledge: From knowledge is handed down by omniscient authority to knowledge is reasoned out through objective and subjective means. (Omniscient Authority)
(2) Certainty of knowledge: From knowledge is absolute to knowledge is constantly evolving. (Certain Knowledge)
(3) Organization of knowledge: From knowledge is compartmentalized to knowledge is highly integrated and interwoven. (Simple Knowledge)
(4) Control of learning: From ability to learn is genetically predetermined to ability to learn is acquired through experience. (Fixed/Innate Ability)
(5) Speed of learning: From learning is quick or not-at-all to learning is a gradual process. (Quick Learning)" (p. 499).

Abd-El-Khalick, Bell, and Lederman (1998) defined nature of science (NOS) as "epistemology of science, science a way of knowing, or the values and beliefs inherent to the development of scientific knowledge" (p.418). There is an agreement about some important aspects of NOS among philosophers, historians, sociologists, and educators (Abd-El-Khalick, 2001). Eight of these aspects were applied in the present study and their definitions are as follows (Abd-El-Khalick et al., 1998; Lederman & Abd-El-Khalick, 1998; McComas & Olson, 1998; Osborne, Collins, Ratcliffe, Millar, & Duschl, 2003; Smith & Scharmann, 1999):

(1) Tentativeness: Scientific knowledge changes with the new data or reinterpretations of existing ones. In the future, there might be a new data by which current scientific knowledge might be inadequate to explain. Scientists are not able to prove a scientific knowledge. They just merely support the existing knowledge and no one can guarantee.
(2) Subjectivity: Considering all the factors (Previous knowledge, experiences, expectations, culture, etc.) influencing scientists throughout their work, scientific knowledge is theory-laden and includes subjectivity.
(3) Experiments, evidences, and skepticism: Although not every scientific discipline enables scientists to conduct experiments (e.g. astronomy) or not all scientific knowledge is constructed as a result experiments (e.g. evolution theory), experiments and evidences are vital in science to reach scientific knowledge. However, scientists, being scientific skeptics, test the reliability of certain kinds of claims by subjecting them to a systematic investigation using some forms of the scientific method.
(4) Creativity and imagination: Logic by itself is not sufficient enough for science and creativity and imagination are required during various phases of a scientific study such as constructing hypothesis, designing different ways for observations and experiments, finally interpretation of data.
(5) Socio-cultural values: Science cannot be isolated from social and cultural environment in which it is conducted. Politics, religion, philosophy, economy, moral values are some of the factors which influence deciding what and how science is conducted, interpreted and developed.

(6) Observations and inferences: Scientific knowledge is the inferences derived from observations. Observations are descriptive statements about phenomena obtained by using senses (e.g., sight, hearing, touch, smell and taste) or some technological devices (e.g., using scale to measure mass). However, inferences are the interpretations of these observations (e.g., Rutherford's atom model based on his observations on the number of alpha particles passed, scattered through and reflected from gold foil).
(7) Law and theory: Scientific theories and laws have different meanings and roles in science. Scientific laws are the descriptive statements about the perceived relationships, regularities, patterns, and generalizations in nature. On the other hand, scientific theories are the explanations for phenomena or laws. There is no hierarchical relationship between theory and law since it is impossible for a theory to become a law considering their role in science. Also, scientific theories and laws are tentative as they are scientific knowledge and there is no status difference between them in terms of reliability and changeability.
(8) Scientific method: There are several common scientific processes such as forming hypothesis, observation, experimentation, interpretation, and hypothesis testing but these processes do not have to follow a specified order.

Although researchers gave different answers to the question of 'What is the nature of science?' and this has led to the emergence of the opinion that there is no single universally accepted definition of the NOS (Abd-El-Khalick et al., 1998; Köseoğlu, Tümay & Buda, 2008; Lederman & Abd-El-Khalick, 1998; McComas & Olson, 1998; Osborne et al., 2003; Smith & Scharmann, 1999), science educators agreed with NOS and epistemology are closely related each other (Lederman, 1992; Schwartz, Lederman, & Crawford, 2004). The definition of Lederman (1992) explains this relationship. He defined NOS as "the epistemology and sociology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge". Like Lederman, some other researchers defined NOS as the epistemology of science (e.g. Abd-el Khalick et al., 1998). Hence, there is a consensus among researchers about the relationship between NOS and epistemological beliefs. In the literature, some researchers emphasized and explored this relationship (e.g. Cho, Lankford, & Wescott, 2011; Özgelen, 2012). For instance, Cho et al. (2011) conducted a study to explore the relationship between college students' epistemological beliefs and views on NOS. The results of their study showed that there were moderate and significant relationships between the dimensions of the two concepts. Also Özgelen (2012) carried out a research to investigate the relationships among 45 pre-service science teacher (PST) s' epistemological beliefs and NOS. The results revealed that there was a statistically significant relationships among some aspects of NOS and epistemological beliefs.

In spite of above-mentioned studies, there is still a lack of research conducted to investigate the relationship between epistemological beliefs and beliefs about NOS. Moreover, both epistemological beliefs and NOS have multiple dimensions and investigation of the relationship among these dimensions in the literature is rare (Cho et al., 2011).

Learners tend to view the knowledge is handed down by authority, knowledge is simple, the knowledge is unchanging, the learning is quick, and learning is innate. These less sophisticated epistemological beliefs may hinder students' views of NOS. Students' epistemological development gives information about their NOS views (Kang, Scharmann, & Noh, 2004). If NOS has been taught as epistemology rather than content, internalization of NOS aspects may be helpful for students to think about epistemology (Driver, Newton & Osborne, 2000; Duschl, Hamilton, & Grandy, 1992). Hence, the relationship between epistemological beliefs and views of NOS should be revealed in order to promote meaningful

learning in science (Qian & Alverman, 2000). Therefore, the main aim of this study is to investigate whether there is a relationship between PSTs' epistemological beliefs and beliefs about NOS or not. It was also aimed to investigate this relationship in a detailed manner by exploring the relationships among sub dimensions of PSTs' epistemological beliefs and sub dimensions of their beliefs about NOS. On this basis, the research question is: What is the relationship between PSTs' epistemological beliefs and beliefs about NOS? Also the two sub-problems of this study are: (1) What are the PSTs' epistemological beliefs? (2) What are the PSTs' beliefs about NOS?

Method

Research Design

Since correlational studies investigate the relationships that may exist among two or more variables as well as their implications for cause and effect (Fraenkel & Wallen, 2009), a correlational design was used in the present study.

Sample

A convenience sample of 219 Turkish fourth grade PSTs (49 males and 170 females) participated in this study. These participants enrolled in elementary science education departments of four public universities located in Kırşehir, Kayseri, Niğde and Sakarya in Turkey. Numbers of students participating to this study from these universities were given in Table 2 respectively. Target population of the study was all fourth grade PSTs enrolled in these universities in the fall semester of 2014-2015. According to the information received from student affairs of the related universities, the target population of this study was about 500 PSTs. The PSTs were enrolled to the present study voluntarily. Therefore, the sample of the study constituted 43.8% of the target population. In the present research, it was aimed to reach more PSTs to make more accurate generalizations based on the results. However, due to some threats such as loss of subjects (mortality), especially in the university located in Kırşehir, the researchers could not reach up the necessary number of PSTs. Likewise, sample size was considered to be up to five times the number of questions in the questionnaire. There should have been approximately 300 participants in terms of numbers of questions, but it cannot be reached because of the reason above.

The mean age of the sample was about 22 years. Distribution of participants based on gender and university was presented in Table 2.

Table 2. Distribution of participants based on gender and university

	Gender					
	Female		Male		Total	
University	Number	%	Number	%	Number	%
Kırşehir	17	85,0	3	15,0	20	9,1
Kayseri	68	76,4	21	23,6	89	40,6
Niğde	45	69,2	20	30,8	65	29,7
Sakarya	40	88,9	5	11,1	45	20,6
Total	170	77,6	49	22,4	219	100,0

Instrumentation

In this study, two instruments were applied to 219 participants respectively: (1) Schommer's Epistemological Questionnaire (SEQ) (Schommer, 1990), (2) Beliefs about NOS Scale (BNOS). Researchers developed BNOS for the present study. SEQ was administered to assess PSTs' epistemological beliefs and, BNOS was administrated to assess same PSTs' beliefs about NOS. Personal epistemology can be domain-general in early years of life. As students are exposed to ideas from family, peers, teachers, and culture, their personal epistemology may become more domain specific. Hence, since pre-service science teachers are affected by their families, teachers, and culture their epistemological beliefs were accepted as domain-specific (Schommer-Aikins, 2002). Moreover, although the original SEQ evaluates personal epistemology at a domain-general level, in this study, SEQ was used as if it is domain-specific version by instructing pre-service science teachers to keep science in their mind as a domain-specific on the SEQ.

Schommer's epistemological questionnaire (SEQ)

In the present study, SEQ, developed by Schommer (1990), was used to determine PSTs' epistemological beliefs. The questionnaire includes 63 items that use a 5-point Likert scale (1= strongly disagree; 5= strongly agree). Items with negative statement were reverse coded. SEQ consists of five hypothetical dimensions and 12 subscales within these dimensions (see Table 3). Schommer carried out numerous validation studies (Schommer, 1990, 1993; Schommer, Crouse, & Rhodes, 1992) and found four factors reflecting personal epistemological beliefs of individuals: Simple Knowledge, Innate Ability, Quick Learning, and Certain Knowledge. Omniscient Authority factor have not been found in Schommer's studies yet. Schommer (1993) conducted the reliability analysis and reported that inter-total item correlations ranges between .51 and .78.

Table 3. Hypothetical dimensions and subscales of Schommer's epistemological questionnaire

Hypothetical dimensions	Subscales	Number of items
Simple knowledge	Seek single answers	11
	Avoid integration	8
Certain knowledge	Avoid ambiguity	5
	Knowledge is certain	6
Omniscient authority	Do not criticize authority	6
	Depend on authority	4
	Cannot learn how to learn	5
Innate ability	Success is unrelated to hard work	4
	Ability to learn is innate	4
	Learning is quick	5
Quick learning	Learn the first time	3
	Concentrated effort is a waste of time	2

Note. Adapted from Schommer's (1990) "Effects of beliefs about the nature of knowledge on comprehension" (p.500).

Schommer (1990) suggested that personal epistemological beliefs vary from "naive" to "sophisticated". For instance, a person who holds naive epistemological beliefs generally believes that knowledge is simple, clear and specific; and learning ability is innate and fixed, and can be transmitted directly to the students. However, a person who holds sophisticated epistemological beliefs generally believe that knowledge is complex, uncertain and tentative,

and can only be gradually constructed by the learner. In SEQ, higher scores (the scores above 2.5) indicate less sophisticated epistemological beliefs in other words relatively naive epistemological beliefs whereas lower scores (2.5 and below 2.5) indicate sophisticated epistemological beliefs (Yılmaz-Tüzün & Topçu, 2013). Throughout the present study the term naive was used to refer to PSTs who have a tendency to believe that truth is certain, simple and able to be transferred by an authority. The term sophisticated was used to refer to PSTs who believe that truth is relative, changing, and actively constructed by the individual (Kardash & Scholes, 1996).

Topçu and Yılmaz-Tüzün (2006) translated and validated SEQ into Turkish by conducting a pilot study with 94 PSTs and factor analysis was computed. Factor analysis structures showed parallelism with Schommer's (1990) study. In their study, translation into Turkish was conducted by two Turkish experts and compared by bilingual experts in field of epistemology in USA (Topcu & Yılmaz-Tüzün, 2006). SEQ was also piloted with 40 PSTs and similar results were captured for factor analysis with Schommer's study. According to their study, by using orthogonal varimax rotation and the eigenvalue greater than one, "principal factoring extraction" generated four factors that account for 54.61% of the variance: innate ability, simple knowledge, certain knowledge, and omniscient authority. They found inter-total item reliabilities for items that compose each factor between 0.20 and 0.60.

Content validity of SEQ. In the present study, three science education experts examined the translated version of SEQ in order to be sure about its content validity. Then, the final form of SEQ was shaped.

Criterion validity of SEQ. In order to determine the criterion validity of SEQ, the results of this study was compared with another study conducted by A in 2014. A moderate positive correlation (r = 0.41, p = 0.02) was found between the total scores of SEQ of A's study (2014) and the present study.

Construct validity of SEQ. In the present study, exploratory factor analysis (EFA) was conducted to validate and define the factor structure of 12 subscales of items of SEQ. Firstly, Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity (BTS) were examined and found as 0.72 and 4460.1 ($p < 0.05$) respectively. Based on these values, it was suitable to run FA. The results of FA revealed four factors that account for 56.4 % of the variance.

Similar with Schommer's (1990) analyses, descriptive titles were given to each factor based on the subscales having factor loadings of 0.50 and higher. Factor 1 was named "Innate Ability" including the subscale dimensions of "ability to learn is innate" and "learning is quick" with the Cronbach's alpha of 0.60. Factor 2 was named "Simple Knowledge" including the subscale dimensions of "seek single answers" and "avoid integration" with the Cronbach's alpha of 0.38. Factor 3 was named "Omniscient Authority" including the subscale dimensions of "cannot learn how to learn" and "do not criticize authority" with the Cronbach's alpha of 0.46. Factor 4 was named "Certain Knowledge" including the subscale dimension of "avoid ambiguity" with the Cronbach's alpha of 0.53. Accordingly, inter-item reliabilities for items of each factor were range from 0.38 to 0.60. Those were lower than Schommer's findings ranging from 0.51 to 0.78. Yılmaz-Tüzün and Topçu (2008) explained two reasons for this lower reliability. Firstly, some subscale dimensions may not load into their hypothesized dimensions. Instead of this, they may be loaded highly to other factors. This indicates that Turkish context participants might not successfully differentiate subscale items because of their close meanings. Secondly, Turkish participants might not understand the items in a way the original questionnaire indicated if the Turkish version cannot captured

the full and literal meaning of the original questionnaire. Since our values are in the acceptable range and close to the values of Schommer's study (from 0.51 to 0.78), we continued our analysis.

Reliability of SEQ. The reliability of total scale including 63 items was found to be 0.72 as measured by the Cronbach's alpha coefficient. This value was acceptable (Pallant, 2007). Reliability coefficients regarding factors were mentioned above.

Beliefs about nature of science (BNOS) survey

In order to measure students' beliefs about NOS, numerous instruments have been developed until today (e.g. VNOS; Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002; Lederman, Wade, & Bell, 1998). Although VNOS is quite, valid and reliable, there are some limitations in determining individuals' NOS profiles and application of VNOS to the large groups (Cho et al., 2011). For instance, VNOS has open-ended questions and respondents need much more time for the replying VNOS. Therefore, in parallel with literature review of the present study, to measure eight aspects of NOS and to reach more participants in a short time, some scales of NOS in the literature were examined to modify BNOS survey. These scales were: (1) Nature of Scientific Knowledge Scale (NSKS) developed by Rubba and Andersen (1978), and translated into Turkish and validated by Kılıç, Sungur, Çakıroğlu and Tekkaya (2005), (2) Nature of Science Scale developed by Cho et al. (2011), (3) Nature of Science Understandings Scale developed by Özcan (2011). These mentioned scales included six, three, and seven aspects of NOS respectively. Therefore, modified version of these scales (BNOS) for this study was aimed to include eight aspects of NOS and much more items to measure much more views of participants about NOS. Hence, considering the above mentioned reasons, the researchers used Beliefs about Nature of Science Scale (BNOS) in the present study. This scale included 51 5-point Likert-type items (1= strongly disagree; 5= strongly agree) and eight sub dimensions (see Table 4): (1) Tentativeness, (2) subjectivity, (3) experiments, evidences, and skepticism, (4) creativity and imagination, (5) socio-cultural values, (6) observations and inferences, (7) law and theory, (8) scientific method. There were negative and positive items in this scale. Negative items of this scale (23) were reverse coded.

In BNOS, in accordance with the terminology developed by Khishfe and Lederman (2006), lower scores (the scores between 1 and 2) indicate naive NOS beliefs, medium scores (the scores between 2.01 and 3.99) indicate transitional NOS beliefs and higher scores (the scores between 4 and 5) indicate informed NOS beliefs of participants. Throughout the present study the term naive was used to refer to PSTs who have a tendency to believe that scientists are objective, scientific theories do not change over time, scientific laws are more certain than theories, science is not affected by culture and society, scientists do not use their imagination and creativity, and there is a universal scientific method. The term transitional implied PSTs' responses move from "naïve view" to "informed view" in an interval step. The term informed was used to refer to PSTs who believe that scientists are subjective, both scientific laws and theories are subject to change, science is affected by culture and society, scientists use their imagination and creativity, and there is no universal scientific method (Liang et al., 2009).

Table 4. Subscales and related items of beliefs about nature of science survey

Subscales	Items
1. Tentativeness	2, 7, 14, 21, 30, 42, 49
2. Subjectivity	3, 8, 10, 22, 33, 45
3. Experiments, evidences, and skepticism	1, 17, 24, 32, 41, 50
4. Creativity and imagination	4, 11, 16, 23, 28, 35, 39, 44, 51

5. Socio-cultural values	6, 13, 25, 36, 47
6. Observations and inferences	12, 18, 27, 37, 46
7. Law and theory	5, 15, 19, 26, 29, 34, 38, 43
8. Scientific method	9, 20, 31, 40, 48

Note. Sample items, respectively (Something that has been researched extensively and "proven scientifically" is no longer subject to change; Even if they focus on the same problem and make investigation, scientists may reach different solutions; skepticism is important for scientists and for the general public; Scientific knowledge is not a product of the human imagination; Cultural values and expectations of the society decide how science shall be approved; The student who said "Enable object place I fell," would have expressed his/her observation; If a theory is continually tested and determined to be valid, it will become a law; All scientific problems must be studied with The Scientific Method).

Content validity of BNOS. In this study, three science education experts examined BNOS to be sure about its content validity, and the final form of BNOS was given.

Pilot Study of BNOS. For the present research, a pilot study was conducted in order to understand the appropriateness of the language, content, instructions, questions, time to apply instrument and scale items (Pallant, 2007). BNOS was conducted to 80 fourth grade PSTs from these four universities. Some analyses were executed to perform reliability and validity purposes. First, reliability of 51 BNOS items was measured by Cronbach's alpha as 0.75. Second, since BNOS was revised based on eight sub dimensions, confirmatory factor analysis (CFA) was conducted to validate and define the factor structure of BNOS for the pilot study. The eight factors had Cronbach Alpha coefficients of 0.64, 0.52, 0.69, 0.66, 0.57, 0.56, 0.51 and 0.50 respectively. These values were acceptable (Pallant, 2007). Lastly, item analysis process was conducted based on item difficulty and discrimination indices for 51 items of the scale. According to this process, difficulty indices ranged from 0.28 to 0.58. The discrimination coefficients are accepted above 0.30 as appropriate for this index. Coefficients between 0.20 and 0.30 needs to be revised. Thus, the four items (item 6, 23, 26 and 45) having item-discrimination index coefficients between 0.20 and 0.30 were revised before being used (Field, 2009).

Item 26 (not revised):
Laws are the claims that are proven absolutely.
Item 26 (revised):
Scientific laws are the scientific expressions that are proven absolutely.

In conclusion, the scale was found valid, therefore, no item needs to be removed from the scale. The given time to complete BNOS (25-30 minutes) was found adequate. Additionally, by asking participants whether there is any confusing expression or whether they have a difficulty in answering the items, a feedback was tried to obtain. Pilot study enabled us to use BNOS for the main study.

Construct Validity of BNOS. In the present study, CFA was conducted to validate and define the factor structure of BNOS. Firstly, Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity (BTS) were examined and found as 0.75 and 3556.2 ($p< 0.05$) respectively. Based on these values, it was suitable to run FA. The results of CFA revealed eight factors that account for 66.1 % of the variance. The eight factors were named as they were in Table 5.

Reliability of BNOS. After checking the normal distribution assumption, reliability analysis for BNOS was conducted. The reliability of total scale including 51 items was found to be 0.76 as measured by the Cronbach's alpha coefficient. The Cronbach's alpha coefficients of the eight sub dimensions were found as 0.59, 0.47, 0.57, 0.64, 0.57, 0.46, 0.57, and 0.47

respectively. Therefore, it can be concluded that BNOS is a reliable instrument (Fraenkel & Wallen, 2009).

Data Collection

Data collection procedure took a month in 2014-2015 Fall. The instruments were conducted during one week in December. PSTs were given approximately 60 minutes to complete two instruments. The instruments were answered in the same class hour in the order of SEQ and BNOS. In order to be sure about the consistency of data collection procedure, a research assistant helped collecting the data at the universities by following the same procedure in each classroom.

Data Analysis

Statistical Package for Social Sciences SPSS was used to analyze the data. First, descriptive statistics were conducted to assess PSTs' epistemological beliefs and beliefs about NOS. Since the reverse scoring was done, participants who got higher scores from SEQ were accepted as having less developed epistemological beliefs. On the other hand, participants who got higher scores from BNOS were accepted as having informed beliefs about NOS. Second, correlational analysis was conducted to explore the relationship between participants' epistemological beliefs and beliefs about NOS.

Results

In below, it was mentioned about the results regarding PSTs' epistemological beliefs, PSTs' beliefs about NOS, and the relationship between PSTs' epistemological beliefs and beliefs about NOS.

Pre-Service Science Teachers' Epistemological Beliefs

Descriptive statistics results showed that participants have the average SEQ score of 2.66. Thus, PSTs have less sophisticated epistemological beliefs (relatively naive epistemological beliefs) since they have the scores above 2.5. Four factors of SEQ on which PSTs scored from highest to lowest: Certain Knowledge (M=3.24), Simple Knowledge (M=2.80), Innate Ability (M=2.65), Omniscient Authority (M=2.05).

Pre-service science teachers' epistemological beliefs on the basis of subscales of SEQ

PSTs' average scores and standard deviations on the sub dimensions of SEQ were seen in Table 5. According to the descriptive statistics results, the participants scored from highest to lowest: Certain Knowledge with an average of 3.24, Simple Knowledge with an average of 2.80, Innate Ability with an average of 2.65, Omniscient Authority with an average of 2.05.

Table 5. PSTs' scores on sub dimensions of Schommer's epistemological questionnaire

Dimension	Mean	SD	Range
Innate Ability	2.65		
Ability to learn is innate	2.73	0.74	1.00-5.00
Learning is quick	2.56	0.51	1.20-3.80
Simple Knowledge	2.80		
Seek single answers	3.05	0.31	2.09-3.91

Avoid integration	2.54	0.38	1.50-3.75
Omniscient Authority	2.05		
Cannot learn how to learn	2.05	0.55	1.00-4.40
Certain Knowledge	3.24		
Avoid ambiguity	3.24	0.55	1.80-4.60

Pre-Service Science Teachers' Beliefs about NOS

The average mean score of eight subscales of BNOS was calculated as 3.53. This score represents that participants have transitional beliefs about NOS since the PSTs have the average scores between 2.01 and 3.99.

Pre-service science teachers' beliefs about NOS on the basis of subscales of BNOS

PSTs' average scores and standard deviations on the sub dimensions of BNOS were shown in Table 6. Eight factors of BNOS on which PSTs scored from highest to lowest: "experiments, evidences, and skepticism" (M=3.97), "tentativeness" (M=3.95), "creativity and imagination" (M=3.75), "subjectivity" (M=3.57), "scientific method" (M=3.48), "socio-cultural values" (M=3.40), "observations and inferences" (M=3.21), "law and theory" (M=2.90).

Table 6. PSTs' scores on sub dimensions of beliefs about nature of science survey

Subscales	Mean	SD
Tentativeness	3.95	0.75
Subjectivity	3.57	0.96
Experiments, evidences, and skepticism	3.97	0.89
Creativity and imagination	3.75	0.89
Socio-cultural values	3.40	0.91
Observations and inferences	3.21	0.92
Law and theory	2.90	1.00
Scientific method	3.48	1.00

The Relationship between Pre-Service Science Teachers' Epistemological Beliefs and Beliefs about NOS

Correlational analysis was conducted to investigate the relationship between epistemological beliefs and beliefs about NOS. According to the results of this analysis, there is a significant moderate negative correlation between PSTs' epistemological beliefs and beliefs about NOS, $r = -0.34$, $n = 219$, $p = 0.00$ (see Table 7).

Table 7. Pearson correlation coefficient (r)

		Total score of BNOS
Total score of SEQ	Pearson Correlation	-0.339**
	Sig. (2-tailed)	0.000
	N	219

Note. ** $p < 0.01$

The relationship between PSTs' epistemological beliefs and beliefs about NOS on the basis of subscales

Correlational analyses were conducted to investigate the relationship between subscales of SEQ and subscales of BNOS. Table 8 shows the Pearson correlation coefficients related to the subscales of SEQ and BNOS. While small and moderate correlations were found between seven subscales of BNOS and the four subscales of SEQ, no statistically significant correlation was found between SEQ subscales and socio-cultural values subscale of BNOS. The results were discussed below basing on the four SEQ subscales.

Innate Ability versus BNOS subscales. According to the results, there is a small negative correlation between the innate ability subscale of SEQ and tentativeness subscale of BNOS, r = -0.15, n = 219, p = 0.03. Similarly, there is a small negative correlation between the innate ability subscale of SEQ and scientific method subscale of BNOS, r = -0.15, n = 219, p = 0.03. Lastly, a moderate negative correlation was found between innate ability and subjectivity, r = -0.31, n = 219, p = 0.00.

S*imple Knowledge versus BNOS subscales.* According to the results of the analyses, there is a small negative correlation between the simple knowledge subscale of SEQ and experiments, evidences, and skepticism subscale of BNOS, r = -0.16, n = 219, p = 0.02. Similarly, there is a small negative correlation between the simple knowledge subscale of SEQ and scientific method subscale of BNOS, r = -0.18, n = 219, p = 0.01. Additionally, a small negative correlation was found between simple knowledge and creativity and imagination, r = -0.22, n = 219, p = 0.00. Lastly, a small negative correlation was found between simple knowledge and subjectivity, r = -0.28, n = 219, p = 0.00. Finally, a moderate negative correlation was found between simple knowledge and tentativeness, r = -0.31, n = 219, p = 0.00.

Omniscient Authority versus BNOS subscales. According to the results of the analyses, there is a small negative correlation between omniscient authority subscale of SEQ and creativity and imagination subscale of BNOS, r = -0.16, n = 219, p = 0.02. Similarly, a small negative correlation was found between omniscient authority and tentativeness, r = -0.21, n = 219, p = 0.00. In addition, a small negative correlation was found between omniscient authority and experiments, evidences, and skepticism, r = -0.22, n = 219, p = 0.00. Also a small negative correlation was found between omniscient authority and subjectivity, r = -0.27, n = 219, p = 0.00. Differently, a small positive correlation was found between omniscient authority and law and theory, r = 0.17, n = 219, p = 0.01.

Certain Knowledge versus BNOS subscales. Based on the results, there is a small negative correlation between the certain knowledge subscale of SEQ and law and theory subscale of BNOS, r = -0.18, n = 219, p = 0.01. Similarly, a small negative correlation was found between omniscient authority and observations and inferences, r = -0.19, n = 219, p = 0.01.

Table 8. Pearson correlation coefficients related to the subscales of Schommer's epistemological questionnaire and beliefs about nature of science survey

			SEQ Factors			
			1	2	3	4
			Innate Ability	Simple Knowledge	Omniscient Authority	Certain Knowledge
BNOS	1 Tentativeness	Pearson Correlation	-0.145*	-0.309**	-0.207**	-0.093

	Sig. (2-tailed)	0.032	0.000	0.002	0.168
2 Subjectivity	Pearson Correlation	-0.309**	-0.281**	-0.266**	-0.046
	Sig. (2-tailed)	0.000	0.000	0.000	0.499
3 Experiments, evidences, and skepticism	Pearson Correlation	-0.064	-0.164*	-0.219**	0.119
	Sig. (2-tailed)	0.346	0.015	0.001	0.078
4 Creativity and imagination	Pearson Correlation	-0.095	-0.217**	-0.159*	0.005
	Sig. (2-tailed)	0.162	0.001	0.019	0.944
5 Socio-cultural values	Pearson Correlation	-0.084	-0.024	-0.056	-0.064
	Sig. (2-tailed)	0.218	0.724	0.412	0.344
6 Observations and inferences	Pearson Correlation	-0.099	-0.045	-0.095	-0.190**
	Sig. (2-tailed)	0.144	0.509	0.161	0.005
7 Law and theory	Pearson Correlation	0.054	-0.026	0.166*	-0.184**
	Sig. (2-tailed)	0.424	0.706	0.014	0.006
8 Scientific method	Pearson Correlation	-0.146*	-0.181**	-0.050	-0.122
	Sig. (2-tailed)	0.031	0.007	0.461	0.071

Note. *p < 0.05; **p < 0.01

Discussion

According to the results, PSTs scored on SEQ from highest to lowest: Certain Knowledge (*M* = 3.24), Simple Knowledge (*M* = 2.80), Innate Ability (*M* = 2.65), and Omniscient Authority (*M* = 2.05). Since the highest score represents relatively naive epistemological beliefs, these results can be interpreted as the participants generally believe knowledge is certain and simple, and learning is innate while they generally believe that the authority is not the superior. Supportively, de Juanas and Beltrán's (2012) and Ismail, Abedalaziz, Hussin, Mohamed, and Saad's (2012) studies found that "Certain Knowledge" dimension had the highest mean score. Moreover, the findings of Eroğlu (2009), A (2014), and Barzideh, Ghasemizad, Khajehei, and Motamed (2012) also revealed that PSTs had higher mean in "Certain Knowledge" dimension compared with other ones. In addition, being parallel with results of the present study, the findings of Findlan's (2006) study revealed that Omniscient Authority had the lowest mean score. Likewise, Perry (1968) reported that students entered the university with less sophisticated epistemological beliefs in that knowledge is simple, certain, and handed down by authority. However, they developed more sophisticated epistemological beliefs throughout their school experiences in that knowledge is

complex, tentative, and acquired through reason and empirical evidence. In the present study, PSTs showed a medium level which means they generally have a developing epistemological beliefs rather than having a more sophisticated epistemological beliefs with respect to four dimensions. This may be explained that PSTs do not have any practical experience on epistemological beliefs yet since they take a superficial instruction based on epistemology and its dimensions because of the overloaded curriculum, the physical conditions and inadequate materials (Hacıeminoğlu, 2014).

Based on the results, the average mean score of eight subscales of NOS was calculated as 3.53. Hence, these scores indicate that PSTs have transitional beliefs on BNOS. It can be stated that although PSTs take NOS lesson on the third grade, they do not have adequate information about NOS because of superficial instruction. In fact, they do not use exactly their NOS information while expressing their views about NOS since they do not have meaningful learning about NOS. In parallel with this study, in other studies, it was also found that pre-service teachers (science, chemistry, biology, and physics) had naive views on NOS (Abd-El-Khalick, 2005; Abd-El-Khalick & Akerson, 2009; Kattoula, 2008; Köseoğlu et al., 2008; Mellado, Bermejo, Blanco, & Ruiz, 2007), pre-service teachers had transitional beliefs on NOS (Kattoula, 2008; Köseoğlu et al., 2008; Mellado et al., 2007), science teachers had naive views on NOS (Aslan & Taşar, 2013; Chun, 2000; Doğan, Çakıroğlu, Çavuş, Bilican, & Arslan, 2011; Hacıeminoğlu, 2014), and science teachers had transitional view on NOS (Hacıeminoğlu, 2014).

The eight factors of BNOS on which PSTs scored from highest to lowest are: "experiments, evidences, and skepticism" (M=3.97), "tentativeness" (M=3.95), "creativity and imagination" (M=3.75), "subjectivity" (M=3.57), "scientific method" (M=3.48), "socio-cultural values" (M=3.40), "observations and inferences" (M=3.21), "law and theory" (M=2.90). Köksal and Çakıroğlu (2010) also found similar mean scores on these subscales except two. They found that elementary science teachers had informed beliefs on the subscale of "creativity and imagination" and naive beliefs on the subscale of "law and theory". This may be because of the teachers mostly learned law and theory in a hierarchical order before constructivism put into practice in schools in Turkey and these teachers did not take any instruction about NOS during their university education process. However, in the present study, PSTs have transitional view on "law and theory" since they instructed based on NOS in university courses.

Since the average SEQ score is lower than 2.5, it can be concluded that PSTs have relatively sophisticated epistemological beliefs and since the average BNOS score is between 2.01 and 3.99, it can be concluded that PSTs generally have transitional beliefs about NOS. A small negative correlation was found between PSTs' epistemological beliefs and beliefs about NOS. In other words, the more sophisticated epistemological beliefs PSTs have, the more informed beliefs about NOS they have. Similarly, results of the study of Cho et al. (2011) showed moderate and significant negative relationship between both epistemological beliefs and NOS beliefs, and between the subscales of epistemological beliefs and the subscales of beliefs about NOS. This relationship can be seen in the definition of NOS since 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).

The results showed that although there were moderate and small correlations between four subscales of SEQ (innate ability, simple knowledge, omniscient authority, and certain knowledge) and seven subscales of BNOS (tentativeness, subjectivity, experiments,

evidences, and skepticism, creativity and imagination, observations and inferences, law and theory, scientific method), no statistically significant correlation was found between SEQ subscales and socio-cultural values subscale of BNOS. PSTs defended the view that development process of science affected by socio-cultural values, but they could not link a relationship between this dimension and epistemological beliefs. The reason for this situation might be that although PSTs have an instruction based on NOS, they do not have any experiences on epistemological beliefs or they do not instruct about epistemology during their university education process. Being at the moderate and significant negative relationship stage in terms of epistemology and NOS in teacher education of Turkey shows that PSTs have not took their thoughts into practice properly. According to the results of the present study, tentativeness and subjectivity are aligned with three aspects of SEQ namely innate ability, simple knowledge and omniscient authority. Supportively, Cho et al. (2011) also found that tentative nature of scientific knowledge is aligned with all aspects of epistemological beliefs. The present study result indicates that PSTs internalized the relationship between tentativeness and the epistemological beliefs best.

According to the results of correlational analyses, as PSTs believe learning is innate, they do not believe that the scientific knowledge is subject to change (r = -0.15). Scientific knowledge is subject to change as new evidences become available. Consequently, a person who believe that the ability to learn is innate would believe that scientific knowledge is not subject to change. Thus, this result is rational. Additionally, innate ability is negatively associated with scientific method (r = -0.15). This means PSTs who believe learning is innate are not likely to recognize that there is more than one scientific method. Similarly, innate ability is negatively related with subjectivity (r = -0.31). Thus, as participants believe learning is innate, they do not believe that science is subjective.

The results revealed that as participants believe knowledge is simple, they do not believe that science is based on experiments and evidences, and skepticism has an important place in science (r = -0.16). Abd-El-Khalick (2005) assume that scientific knowledge is generated through "critical, negotiated, and collaborative inquiries that are propelled by scientists' imaginations and bound only by their observations of the natural world" (p. 17). Starting from this point of view, scientific knowledge is the knowledge derived from observations and evidences of natural world. Hence, science is unique compared to other ways of knowing because scientific knowledge is based on empirical evidence filtered by human interpretation (Lederman, 1992) and this makes scientific knowledge complex rather than simple. For this reason, finding of present study is meaningful. As another result, it was found that as participants believe knowledge is simple, they do not believe that there is more than one scientific method (r = -0.18). Being a common misunderstanding, some people suppose that there is a single scientific method followed by all scientists since scientific method is often taught in science courses as a simple way to understand the basics of scientific testing (Tunç-Şahin & Köksal, 2010). However, scientists do not always follow single scientific method on their studies, they generally reach the complex knowledge rather than simple using more than one scientific method. Hence, it is rational that PSTs who believe knowledge is not simple also believe that there is more than a single scientific method. Moreover, as participants believe knowledge is simple, they do not believe that creativity and imagination are important in science (r = -0.22). This means PSTs who assume scientific knowledge is simple are not likely to recognize that science is a non-linear and complex process which requires creativity and imagination. Additionally, as participants believe knowledge is simple, they do not believe that science is subjective and subject to change (r = -0.28). Science is a process to produce knowledge. This process depends on making careful observations and inferences of phenomena and inventing theories for making sense out of these observations. Change in

knowledge is inevitable as new observations challenge prevailing theories. No matter how well one theory explains a set of observations, it is possible that another theory may fit better. Therefore, the scientist assume that there is no complete and absolute truth, and no simple knowledge (Matthews, 1994). Lastly, a moderate negative correlation was found between simple knowledge and tentativeness (r = -0.31). This means PSTs who believe scientific knowledge is simple are not likely to recognize that scientific knowledge subject to change. Findings of the study of Cho et al. (2011) supported this result. Knowing that science is a complex process rather than a simple one, it is meaningful to think that scientific knowledge changes in time.

Based on the results, as participants do not believe the omniscience of the authority, they believe that the scientific knowledge is subject to change (r = -0.21), and creativity and imagination is very important in science (r = -0.16). Additionally, as participants do not consider omniscience of the authority, they reflect that science is based on experiments and evidences, and skepticism has an important place in science (r = -0.22), and they also consider that science is subjective (r = -0.27). Correlation values between omniscient authority and sub dimensions of NOS in the present study indicate that student-centered teaching approaches have not been implemented at the desired level in science curriculum in Turkey. Going along findings of the present study, Belenky, Clinchy, Goldberger and Tarule (1986) also stated that the passive acceptance of knowledge is closely related to the beliefs of knowledge is certain and authorities have the knowledge. As a different result, although PSTs do not believe omniscience of the authority, they believe that there is a hierarchy between law and theory (r = 0.17). The reason for this finding may be explained by the fact that PSTs in Turkey learn theoretically the relationship between law and theory and they still fail to give an example for the hierarchy between law and theory. In other words, PSTs cannot promote meaningful learning on this hierarchy.

According to the results, since participants consider knowledge is not certain, they do not suppose that there is a hierarchy between law and theory (r = -0.18). Being another finding, as PSTs assume that knowledge is not certain, they conceive observations and inferences are so important in science (r = -0.19). Science depends on making observations and inferences of a phenomena and the knowledge changes as new observations produce new theories. Hence, it becomes meaningful that PSTs assume that there is no absolute truth and certain knowledge. Consequently, considering all of the evidence obtained from multiple correlation analysis, it was clearly seen that NOS and epistemological beliefs are related with each other.

Suggestions

In this study, it was aimed to explore the relationship between epistemological beliefs and views on NOS of PSTs. However, there were some limitations for this study. For instance, to better understand this relationship, the structure equation modeling techniques should be applied for the analysis of data. Also, more participants should be included in future studies to make more accurate generalizations based on the results.

In recent years, although having a compulsory course about NOS in education faculties is an important improvement, considering the findings of the present study it was clearly seen that this is not sufficient alone. For this reason, course content should be enriched. If NOS has been taught as epistemology rather than content, internalization of NOS aspects may be helpful for students to think about epistemology (Driver et al., 2000; Duschl et al., 1992).

Being a suggestion, a teaching strategy that is fed into epistemological beliefs and NOS can

be planned and also an experimental study that investigate the effect of this strategy on students' achievement can be conducted.

If these concepts are also discussed in primary and secondary education in detail, the next generation will come to education faculties being more informed and adequate. Thereby, teacher of the future will also be more knowledgeable about these issues and the more knowledgeable generation will be bred up.

Understanding and teaching NOS and epistemological beliefs is one of the main goals of science education. However, researches revealed that the concepts related to NOS cannot be taught in a short period of time since it is a long and time-consuming process (e.g. Lederman, 2007). The situation for epistemological beliefs is also the same as NOS (e.g. Schommer-Aikins, 2002). Hence, especially PSTs must get the necessary information and concepts about NOS and epistemological beliefs during their undergraduate education. In addition, in order to learn how to teach these issues, teaching materials and activities should be described in a practical way in PSTs' courses. In this way, they should be more successful in providing course and laboratory materials of their future classes and helping their students to have more reliable and up-to-date information about these issues.

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