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PRESERVICE SCIENCE TEACHERS' OPINIONS ABOUT SCIENTIFIC AND NON-SCIENTIFIC KNOWLEDGE*

FEN BİLGİSİ ÖĞRETMEN ADAYLARININ BİLİMSEL VE BİLİMSEL OLMAYAN BİLGİ İLE İLGİLİ GÖRÜŞLERİ

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Abstract

Since ancient times, the nature of science and the difference between science and non-science have been important topics for study. Today in science education considerable emphasis is given to the training of scientifically literate individuals who can make use of critical thinking skills. On the other hand, recent studies have revealed a prevalence of non-scientific beliefs.

This study examines preservice science teachers' opinions about the characteristics of science and about scientific and non-scientific knowledge. Forty nine preservice science teachers in the Science Teacher Education Department at one university participated in the study. Data were obtained from their responses to open-ended questions and to a questionnaire related to scientific literacy. The open-ended questions probed the preservice teachers' opinions about science and about scientific and non-scientific knowledge. The questionnaire determined their scientific literacy levels. Both qualitative and quantitative data analyses were conducted. Analysis of the open-ended questions was done by content analysis. The frequency of responses was calculated using the Scientific Literacy Scale. It was found that preservice

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[*] Bu makale Crosscheck sistemi tarafından taranmış ve bu sistem sonuçlarına göre orijinal bir makale olduğu tespit edilmiştir.

science teachers have problems identifying some of the characteristics of science and scientific knowledge such as changeability and testability. They have also misconceptions related to scientific theories and scientific laws. However, most of them aware importance of some of the scientific criterias such as creativity, imagination and socio-cultural values. Some possible implications are suggested in the light of these results.

Key Words: Scientific and non-scientific knowledge, Characteristics of science, Preservice science teachers

Öz

Antik çağlardan beri bilimin sınırlarının belirlenmesi filozoflar için önemli bir konu olmuştur ve bu konu hala önemini korumaktadır. Günümüzde fen eğitiminde tüm dünyada bilimle ilgili konularda eleştirel düşünme becerilerini kullanabilmeleri için bireylerin bilimselokuryazarlık eğitimine önemli vurgu yapılmaktadır. Buna karşılık, son yıllarda yapılan çalışmalar bireylerin bilimsel olmayan alanlara yönelik inançlarının yüksek düzeyde olduğunu göstermektedir.

Bu çalışmada fen bilgisi öğretmen adaylarının bilimin özellikleri, bilimsel ve bilimsel olmayan bilgi ile ilgili görüşleri araştırılmıştır. Çalışmaya bir üniversitenin Fen Bilgisi Öğretmenliği Ana Bilim Dalı'nda öğrenim gören 49 fen bilgisi öğretmen adayı katılmış ve veriler bu öğretmen adaylarının açık uçlu sorulara ve bilimsel okuryazarlık ile ilgili ölçeğe verdikleri yanıtlardan elde edilmiştir. Açık uçlu sorular öğretmen adaylarının bilim, blimsel ve bilimsel olmayan bilgi ile ilgili görüşlerini değerlendirmek amacı ile uygulanmıştır. Bilimsel okuryazarlık ölçeği ise öğretmen adaylarının bilimsel okuryzarlık düzeylerini belirlemek için uygulanmıştır. Veri analizi için nicel ve nitel analiz yöntemlerinden yararlanılmıştır. Açık uçlu soruların analizi için içerik analizi yapılırken ölçek analizinde verilen yanıtların sıklığı hesaplanmıştır. Araştırmadan elde edilen sonuçlar fen bilgisi öğretmen adaylarının bilim ve bilimsel bilginin özelliklerini belirlemede problem yaşadıkları (değişebilirlik, denenebilirlik) tespit edilmiştir. Aynı zamanda bilimsel teoriler ve kanunlar ile ilgilikavram yanılgılarına sahip oldukları belirlenmiştir. Buna karşılık, öğretmen adaylarının yaratıcılık, hayal gücü ce sosyo-kültürel değerler gibi bazı bilimsel kriterlerin öneminin farkında oldukları bulunuştur. Araştırma sonucunda fen bilgisi öğretmen adaylarının alanları ile ilgili olarak ve bilim ve bilimsel bilginin yapısı ve özellikleri hakkında bilgi sahibi olmasının gerekliliği önerilmiştir.

Anahtar Kelimeler: Bilimsel ve bilimsel olmayan bilgi, Bilimin özellikleri, Fen bilgisi öğretmen adayları

Introduction

Although the influence of science in this century has been great, some fields of inquiry are seen as being unscientific. Various explanations have been offered to distinguish scientific from non-scientific knowledge. The issue, referred to as the demarcation problem, has been examined by philosophers of science for many years as they attempt to clarify the nature of scientific and non-scientific knowledge, the characteristics and universal qualities of science, and the difference between scientific and non-scientific opinion (Uslu, 2011).

It is generally agreed that science develops a useful understanding of the physical world and obtains reliable information through research based on observation and experiment (Erçek, 2008; Settlage & Southerland, 2012; Uslu, 2011). Science is also seen as a problem-solving activity in the context of observations and hypotheses. In other words, science employs a test-mistake-debugging process (Yıldırım, 2008, p. 127). Yıldırım emphasized the most important features of science and stressed that no matter how much it seems to be verified, each theory or hypothesis cannot lead to certainty. That is, it cannot be proved since it is open to falsification by new studies.

According to Pena and Paco (2004), knowing science does not mean simply knowing scientific facts. It means understanding the nature of science, the criteria of evidence, the design of meaningful experiments, the evaluation of possibilities, the development of theories, and many other components of scientific research. On the other hand, non-scientific knowledge cannot be developed by the scientific method and a scientific perspective. Rather, it is based on beliefs, values, and ideologies (Thagard, 2011; Uslu, 2011). Non-scientific knowledge includes enterprises, doctrines and activities which are not scientific but which may be misrepresented as scientific, even when unsupported by research that meets scientific standards (Efthimiou & Llewellyn, 2004; Erçek, 2008; Uslu, 2011). Such non-scientific knowledge, as described in the literature, includes metaphysical doctrines, pseudoscience, conspiracy theories, and ideologies (Uslu, 2011). Yıldırım (2008, p. 43) defined metaphysics as an attempt to understand the world through intellectual activity and intuition and to express the truth behind events according to one or more principles. He claims that incompatible metaphysical systems are born because this field cannot be examined in a factual way. On the other hand, Beyerstein (1995) described pseudoscience as a field that tries to appropriate the prestige of genuine sciences by copying their outward trappings and protocols. Pena and Paco (2004) stressed that the underlying methodology, logic, and epistemology of pseudoscience do not belong to science. These researchers also indicated that people who believe that pseudoscience is scientific often ignore the underlying philosophy and methodology of science. Pseudoscientific claims have some questionable characteristics such as the use of uncontrolled experiments, specially selected samples, distortion of observation, and biased interpretation of data (Uslu, 2011). In addition, they tend to incorporate story-based features rather than scientific reasoning (Erçek, 2008). Usually they appeal to strong emotional needs such as cures for diseases, assurances about life after death, satisfaction of spiritual hunger, and promises to provide things people do not have (Sagan, 2010, p.14; Wynn & Wiggins, 2002, p. 28). The aim of science, on the other hand, is not to provide emotional satisfaction, but to describe fundamental processes in nature (Yıldırım, 2008, p. 454).

Uslu (2011) stated that distinguishing pseudoscience from science is more difficult than distinguishing non-science from science, because pseudoscience makes apparently scientific claims. Consequently, such claims can have an effect on people. In studies intended to determine the boundary between scientific and non-scientific areas of knowledge, researchers have focused on various criteria with regard to science and scientific knowledge (Carter & Wheldall, 2008; Efthimiou & Llewellyn, 2006; Thagard, 2011; Uslu, 2011, Yıldırım, 2008). Thagard (2011) indicated that although identifying such criteria is not sufficient to create a boundary between science and pseudoscience, it does provide a profile that allows us to make a distinction between them. In the philosophy of science, the descriptive characteristics of a science are listed as follows (Yıldırım, 2008, p. 405):

1. it can be described as an objective phenomenon that requires explanation
2. it is factually testable in terms of explanatory hypotheses or theories
3. it is suitable for new perspectives.

According to these features, firstly, scientifically accepted knowledge must include a group of phenomena that can be described. There will be a particular hypothesis or theory to explain these phenomena or phenomenological relations. Secondly, the hypothesis or theory must be testable (Yıldırım, 2008, pp. 407). Testability means that the obtained knowledge is publicly available, transparent, and the accuracy and validity of that knowledge can be monitored in an objective way (Uslu, 2011). Carter and Wheldall (2008) also stressed the importance of testability and falsifiability with regard to scientific claims. Yıldırım (2008, pp. 408) indicated that, due to the possibility of finding confirmatory evidence for every proposition, a claim or theory is not assessed only by verification, but also by falsifiability. Yıldırım (2008, pp. 42-43) stated that scientific reasoning is the most obvious feature which distinguishes science from non-science, reasoning refined by continuous testing and correction. The third criterion of scientific knowledge is its openness to change due to new facts or perceived phenomena. This is an indication that science is progressive and open to development (Uslu, 2011).

Research has shown that students, like people in general, have high levels of belief concerning pseudoscience and paranormal phenomena (Kallery, 2001; Pena & Paco, 2004; Diaz-Vilela & Gonzalez-Alvarez, 2004; Farha & Steward, 2006; Kallery, 2001; Pena & Paco, 2004). Kallery (2001) found that most of the teachers studied believed that astrology and astronomy are scientific. Another study found that students tended to accept some paranormal claims (Diaz-Vilela & Gonzalez-Alvarez, 2004), including psychic abilities, spiritual healing, haunted houses, and spirits (Farha & Stewart, 2006). Researchers found no relationship between students' paranormal beliefs and their educational level (Sürmeli & Saka, 2010). These studies indicate that individuals who do not understand science and scientific knowledge may have a tendency to turn to irrational doctrines and obsessions. In order to discourage this tendency, it is important to teach children at an early age about science and scientific knowledge, and to show them how to distinguish science from other fields. Science teachers have an important role to play in providing children with this knowledge. To that end, it is also important that teachers themselves know the characteristics of science and are able to distinguish science from non-science. Students in science courses should not only gain knowledge of scientific topics but should also acquire scientific literacy, which is an important goal of science education (Özdem et al., 2010). In this study we aim to find out how preservice teachers distinguish science from non-science.

Method

Sample

The study was conducted during the Spring semester of the 2011-2012 academic year. The sample consisted of 49 preservice science teachers during their second year of Science Teacher Education at one university.

Research Instrument

Data for the study were obtained from responses to a questionnaire and open-ended questions related to scientific literacy. The open-ended questions were asked to determine what pre-service teachers think about science/scientific knowledge, how they distinguish science from non-science, and what they know about the characteristics of science, scientific knowledge, and non-science.

The characteristics of science identified in The Scientific Literacy Scale, developed by Akgün (2010), include tentativeness, multiple ways to do scientific research, changeability, creativity, social-cultural values, observations, inferences, theories, and laws. In this study, this scale was administered to preservice science teachers. The Likert-type scale consisted of 28 items. The reliability of the scale was 0.66 in the original study and 0.65 in this study.

Analysis

Both qualitative and quantitative data analysis were used in this study. Statistical analysis was carried out by means of SPSS 17 for quantitative data analysis, and descriptive statistics were used to examine the frequencies.

Qualitative data analysis employed content analysis that entailed coding and creating themes related with preservice science teachers' responses to the open-ended questions. The answers were examined by the two researchers separately. Based on their examinations, relevant themes were created and compared in order to find similarities and differences. After reaching consensus on the themes, both of the researchers re-examined responses and checked the relevant themes, and then the consistency between the researchers was evaluated. To examine reliability, the formula suggested by Miles and Huberman (1994) was applied (Reliability = Number of agreements / Total number of agreements + Disagreements).

The finding (0.88) revealed that the coding procedure was reliable.

Findings

Table 1. Frequency values of preservice science teachers' opinions on scientific knowledge

Scientific knowledge should be …	**f**
based on experiments and observations	24*
based on research and investigations	9
based on scientific criteria	1
accurate and certain/not changed	19
verified/proven	28*
accepted by everyone	20*
based on scientific subjects such as physics, chemistry, biology and medicine	6
theory or law	12

Table 1 shows the frequency values of preservice science teachers' opinions about scientific knowledge. Since some of the participants' answers were put into more than one category, the total number of participants specified is more than 49. As seen in Table 1, more than half of the participants (f: 28) thought that scientific knowledge should be proved or verifiable. Results also showed that scientific knowledge should be proved by experiments and observations (f: 24). In addition, 20 participants thought that universal acceptance was a criterion for scientific knowledge, that the same conclusions should be reached anywhere in the world, and that the same inferences pertaining to the natural world should be perceived by everyone in the same way. Of the 49 participants, 19 indicated that certainty is a characteristic of scientific knowledge as follows:

'Scientific knowledge is legalized and irrefutable – scientific knowledge is unquestionably true, accurate'; '…knowledge must be accurate and verifiable'; '…accuracy of scientific knowledge should not be changed by other factors'; '…scientific knowledge is difficult to change'; '…scientific knowledge is not falsifiable'.

Just one of the participants expressed both of the two characteristics of scientific knowledge as follows:

'…accuracy of scientific knowledge should be revealed. Scientific knowledge should give the same results in each experiment and observation, and, most importantly, it should be develop over time..

Table 2. Percentage values of Scientific Literacy Scale

Changeability/ Uncertainty	**Strongly disagree**	**Disagree**	**Uncertain**	**Agree**	**Strongly agree**
Science produces changeable, imprecise conclusions (inferences).	14.3	36.7	10.2	34.7	4.1
Science proves the facts precisely.	4.1	8.2	26.5	42.9	18.4

Table 2 shows the data obtained from the scientific literacy scale. While 36.7% of the participants indicated that they disagreed with the statement 'Science produces imprecise inferences (conclusions)', 34.7% indicated that they agreed with the statement. In view of results obtained from the open-ended questions, it can be inferred that preservice science teachers consider scientific knowledge to be unchangeable, proven, and accurate.

Table 2 also shows that 42.9% of the participants agreed with the statement 'Science proves the facts precisely'. The results also show that most of the participants (f: 28) thought that the accuracy of scientific knowledge is definitely proven. Some of the expressions which support this opinion are as follows:

'…Any knowledge which is demonstrable is scientific'; '…knowledge which has been proved and accepted by everyone is scientific'; '…knowledge which is unproven and not been accepted by everyone is unscientific'.

Only one participant claimed that knowledge can be falsified or verified: 'Scientific knowledge is knowledge which can be verified and falsified with positive sciences".

In their responses to the open-ended questions, most of the participants emphasized the importance of experimental studies and shared the opinion (Table 1; f: 24) that scientific knowledge should be based on observations and experiments. One expression of this opinion is as follows:

‘If as a result of experiments there is sufficient information, then it is scientific…, but we cannot say that knowledge based on assumptions is scientific, without doing experiments’.

However, participants who identified scientific knowledge as proven information also mentioned that experiments should be done in order to prove the information. They stated this opinion as follows:

‘...experiments should be done to accept the accuracy of the knowledge’.

As seen in Table 1, besides experiments and observations, participants also emphasized the need for research and investigation:

‘Scientific knowledge is knowledge obtained through experiment, observation, and activities based on research’.

Such responses indicated that accurate results obtained from experiments and observations should be used to prove knowledge.

Table 3. Percentage values of Scientific Literacy Scale

Experimental background	**Strongly disagree**	**Disagree**	**Uncertain**	**Agree**	**Strongly agree**
Scientists often think of experiment to make a provision.	4.1	30.6	20.4	40.8	4.1
An experiment can prove a theory.	2	8.2	16.3	55.1	18.4
Observations and Inferences					
Scientists accept theoretical forms which cannot be seen directly.	2	24.5	42.9	18.4	6.1
The process of creating knowledge based on inferences belongs to the natural world and to observations.	2	10.2	16.3	57.1	14.3

In addition to data obtained from open-ended questions, data obtained from the Scientific Literacy Scale, (see Table 3) show that 40.8% of the participants indicated that they did not agree with the statement 'In order to make a provision an experiment should be considered'. On the other hand, 30.6% of disagreed with the statement. Furthermore, 55.1% agreed with the statement 'An experiment can prove a theory'.

Table 3 also shows that, while 42.9% of the participants are uncertain about the statement 'Scientists accept theoretical forms which can not be seen directly', 57.1% agreed with the statement 'Scientific process is based on inferences and observations'.

Table.4. Percentage values of Scientific Literacy Scale

Creativity	**Strongly disagree**	**Disagree**	**Uncertain**	**Agree**	**Strongly agree**
Scientists use their imagination and creativity in several stages of scientific research.	2	8.2	8.2	51	30.6

In their responses to open-ended questions, participants emphasized that scientific knowledge should be objective and not subjective. Some expressed their opinions as follows:

'I make discriminations based on objective approaches rather than subjective considerations'; '…all objective judgements whose accuracy have been proved are called scientific knowledge'.

Although they did not mention creativity and imagination in their responses, analysis of the scale (Table 4) shows that 51% of the participants agreed that creativity and imagination in research contribute to scientific knowledge.

Table 5. Percentage values of Scientific Literacy Scale

Multiple ways to do scientific research	**Strongly disagree**	**Disagree**	**Uncertain**	**Agree**	**Strongly agree**
Science has a single form of research called the scientific method.	14.3	36.7	24.5	22.4	2
Scientific knowledge is created in many different ways (observation, analysis, research in library).	2	-	-	57.1	40.8
Socio-cultural values					
Scientists' training, experiences, ideas, studies and philosophies effect their perceptions data they obtained and their interpretations	-	4,1	4,1	61,2	30,6
Scientists configure the theories in order to guide future studies.	-	2	12,2	77,6	8,2

In their responses to open-ended questions, participants did not mention the effect of socio-cultural values and multiple paths to scientific knowledge (Table 1). On the other hand, results of the scale show that while 36.7% did not agree with the statement 'Science has a single form of research called the scientific method', 22.4% agreed with and 24.5% were uncertain about this statement (Table 5). In addition, table 5 shows that almost all of the participants (97.8%) agreed that scientific knowledge can be reached through observation, analysis, library research, and experimentation. As seen in Table 5, participants were of the opinion that scientific studies are influenced by scientists' training, experiences, ideas, studies, and philosophies (61.2%). They also agreed that in order to guide future scientific studies, scientists configure the theories (77.6%).

Table 6. Percentage values of Scientific Literacy Scale

Theories and Laws	**Strongly disagree**	**Disagree**	**Uncertain**	**Agree**	**Strongly agree**
Scientific theories are not facts; they are explanations.	12.2	24.5	28.6	30.6	4.1
Scientific law is a comprehensive and verified theory.	-	8.2	12.2	44.9	34.7
Scientific laws define the relationship between observable events, but cannot explain them.	14.3	57.1	22.4	6.1	-
Scientists create models or theories with their explanations.	-	8.2	6.1	75.5	10.2

From the responses to open-ended questions it was determined that some of the participants (Table 1, f: 8) have the opinion 'Knowledge that has accuracy carries the nature of law'. Additionally, some have the opinion (Table 1, f: 4) 'Scientific knowledge should be theory or law', or 'If it is in the stage of theory and law, everything is scientific'. However, there are also some participants who define law as 'verified theory'.

In addition to these results, analysis of the scale shows that participants considered scientific laws to be comprehensive and verified theory (44.9%). However, 57.1% disagreed that scientific law defines the relationship between observable events but is insufficient as an explanation (Table 6).

Discussion and Conclusion

While the debate continues to draw a line between science and non-science and attempts to define scientific criteria, at least some researchers agree on some of the criteria (Smith & Scharman, 1999; Lederman, Abd-El-Khalick, Bell & Schwartz, 2002, McComas et al., 1998). Among these criteria, the most prominent are *changeability* and the *progression* of scientific knowledge. Therefore, future studies of the nature of science will have these and other criteria to bear in mind, and individuals will need to turn scientific studies in this direction. Many researchers (Holdbrook, 2007; Lederman & Lederman, 2004; McComas et al., 1998) have mentioned the importance of education in order to understand the nature of science. In this study, we have tried to determine what kind of perceptions preservice science teachers' have with regard to science and scientific criteria.

The results of this research show that some of the preservice science teachers studied had contradictory opinions about *changeability,* which is the most important characteristic of scientific knowledge. In addition, it was also found that preservice science teachers have traditional opinions on *accuracy and certainty* and the *invariance* of scientific knowledge. This result is consistent with the results of some earlier studies (Lederman, 1992; Bell, 2004) related to scientific criteria. It has been said that the reason preservice science teachers think like this is that their education has been based on a traditional approach that emphasizes the need to memorize (Irez, 2008; Bell, 2004). This training causes them to perceive scientific knowledge as being based on experiments that result in accurate and constant information. This might cause them to misinterpret the nature of science as static and boring. Researches have emphasized that scientific explanations are based on a great deal of experimental and observational evidence. These studies reveal that students see the actions of science, including evidence of dynamic, changing and interesting phenomena but are unaware of the tentativeness of scientific explanations (Settlage & Southerland, 2012, p. 44). In this study, the preservice science teachers agreed that scientific knowledge should be *testable* and *observable*. They perceived the importance of doing experiments, but they were also of the opinion that these observations and experiments should be precise and constant and are undertaken in order to prove scientific knowledge. These results are in line with those of Ryder and his colleagues (1999).

Earlier studies have shown that many teachers and students believe in the *hypothesis-theory-law* sequence which is now considered to be an incorrect representation of the scientific process in many textbooks (Rubba & Harkness, 1993; Kılınç, 2010; Tatar, Karakuyu, Tüysüz, 2011; Shiang-Yao & Lederman, 2007), especially as revealed by Keesler (1945) (cited in Irez, 2008). In contrast with the above descriptions related to theory and law, hypotheses are trial explanations whose fates are determined by testing (Settlage & Southerland, 2012, p. 45). Continuous confusion related to these scientific concepts may have a negative effect on the acquisition and development of scientific knowledge. In this study, the results indicate that preservice science teachers who have opinions regarding unchangeability and certainty of scientific knowledge have also misconceptions about *theories* and *laws* (Tatar, Karakuyu & Tüysüz, 2011). They also have opinions with regard to *invariance* and the *accuracy* of laws. In addition, this study showed that preservice science teachers perceive *theory as a sub-step of the law* and they have the misconception that theory becomes scientific law when it is proven. This misconception has been encountered in various earlier studies (Turgut, 2009; Settlage & Southerland, 2012, p. 45; Shiang-Yao & Lederman, 2007). Hence, preservice science teachers perceive scientific laws as being unchanging and indisputable. However, while a law is considered to be a specific, straightforward and simple description of nature, theories are the most powerful, and most theories support explanations for natural phenomena (Settlage & Southerland, 2012, pp. 44-45). Therefore, theories and laws are accepted as different concepts in science. Mumba and his colleague (2008) stressed the importance of instruction regarding scientific theories and laws. They found that chemistry teaching fellows who had uninformed views concerning these characteristics of scientific knowledge had developed a better understanding through instruction.

Creativity and imagination are essential qualities of the scientist when designing experiments for testing hypotheses, developing ways to gather evidence, and interpreting data to develop reasonable explanations (Settlage & Southerland, 2012, pp. 36). Results of this study reveal that half of the preservice science teachers agreed with the importance of *creativity* and *imagination* in the constitution and development of scientific knowledge. In addition, the results show that most preservice science teachers were aware of the influence of *socio-cultural values,* including scientists' ideas, experiences, and education, on scientific knowledge. In their comments, however, they did not mention scientific *creativity* and *socio-cultural values* that affect scientific knowledge. In other studies, also, the participants did not mention the socio-cultural structure of scientific knowledge (Özcan, 2011). Researchers have stated that ignoring scientists' imagination, creativity, and subjectivity, all potential influences on scientific knowledge, may have a negative effect on the development of science (Akerson, Abd-

El-Khalick & Lederman, 2000). Similarly, if scientific criteria are not adequately dealt with during teacher training, the consequence is likely to be a negative effect on future students (İrez, 2008).

According to these results, the preservice science teachers perceive science as accurate and certain knowledge obtained through experimentation. They emphasized tentativeness (testability) but mostly were unable to identify other characteristics of science adequately. Instead, they tended to see science as static, failing to develop new theories or applications. Çoban (2010) also indicated that preservice science teachers have inadequate understanding of science, basing their understanding mostly on phenomena and empirical observation. Their opinions may be associated with the training they received from primary education onwards (Shapira, 1989; Lucas & Roth, 1996). Their scientific knowledge perception is important because this knowledge might influence their classroom practice (Lederman & Zeidler, 1987). For this reason, it is important that science teachers and preservice teachers receive training in order to understand the structure and characteristics of scientific knowledge. A more contemporary perspective is important for their development as teachers and the education of students in the future.

REFERENCES

AKERSON, V.L., ABD-EL-KHALİC, F., LEDERMAN, N.G. (2000). Influence of a reflective explicit activity-based approach on elementary teacher's conceptions of nature of science. *Journal of Research in Science Teaching*, *37*(4), 295-317.

AKGÜN, Ö. (2010). *Öğretmen adaylarının fen ve teknoloji laboratuvarına ilişkin görüşleri ve bilim okur-yazarlığı*. Yüksek Lisans Tezi, Fırat Üniversitesi Fen Bilimleri Enstitüsü, Elazığ.

BELL, R. L. (2004). *Persuing pandora's box*. In L. B. Flick &N. G. Lederman (Eds.), Scientific Inquiry and Nature of Science. pp.427-446.

BEYERSTEİN, B. L. (1995). *Distinguishing science from pseudoscience*. Monograph prepared for the Center for Curriculum and Professional Development. Victoria, BC: Simon Fraser University.

CARTER, M., WHELDALL, K. (2008). Why can't a teacher be more like a scientist? Science, pseudoscience and the art of teaching. *Australasian Journal of Special Education, 32*(1), 5-2.

ÇOBAN, G.U. (2010). The scientific understanding level of prospective science teacher. *Journal of Baltic Science Education*, *9*(3), 237-254.

DÍAZ-VİLELA, L., ÁLVAREZ-GONZÁLEZ, C.J. (2004). Differences in paranormal beliefs across fields of study from a spanish adaptation of Tobacyk's RPBS. *The Journal of Parapsychology*, *68*(2), 405-421.

EFTHİMİOU, C.J., LLEWELLYN, R. A. (2006). Is peudoscience the solution to science literacy? *Physics Education*. En línea: http://arxiv.org/PS_cache/physics/pdf/0608/0608061v1.pdf. (15.01.2013)

ERÇEK, A. (2008). *Nörokuantoloji (Kuantum beyin).* Gazi Üniversitesi Orta Öğretim Fen ve Matematik Alanları Eğitimi. w3.gazi.edu.tr/~mkaradag/tezler/aydanercek.pdf. (12.01.2013)

FARHA, B., STEWARD, G.J. (2006). Paranormal beliefs: An analysis of college students. *The Skeptical Inquirer*, *30*(1), 37-40.

HOLDBROOK, J., RANNİKMAE, M. (2007). The nature of science education for enhancing scientific literacy. *International Journal of Science Education, 29*(11), 1347-1362.

İREZ, S., TURGUT, H. (2008). Fen eğitimi bağlamında bilimin doğası. Ö.Taşkın (Ed.), *Fen ve Teknoloji Öğretiminde Yeni Yaklaşımlar* (p.233-263). Ankara: Pegem Akademi.

KALLERY, M. (2001). Early-years educators' attitudes to science and pseudo-science: the case of astronomy and astrology. *European Journal of Teacher Education*, *24*(3), 329-342.

KILINÇ, E. (2010). *Ortaöğretim öğrencilerinin bilimin doğası hakkındaki bilgi yapılarının kavram haritası yöntemiyle incelenmesi.* Yayınlanmamış Yüksek Lisans Tezi, Gazi Üniversitesi, Eğitim Bilimleri Enstitüsü, Ankara.

LEDERMAN, N.G., and LEDERMAN, J.S. (2004). Revising instruction to teach nature of science. *The Science Teacher 71*(9):36-39.

LEDERMAN, N.G., ABD-EL-KHALİCK, F., BELL, R.L., SCHWARTZ, R.S.(2002). Views of nature of science questionnaire: Towards valid of nature and meaningful assessment of learner's conceptions of nature of science. *Journal of Research in Science Teaching, 39*(6), 497-521.

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

LUCAS, K.B. & ROTH, W.M. (1996). The nature of scientific knowledge and student learning: Two longitudinal case studies. *Research in Science Education, 26*, 103-129.

MCCOMAS, W.F., CLOUGH, M.P., & ALMAZROA, H. (1998).The role and character of the nature of science in science education.*Science & Education, 7*(6), 511-532.

MİLES, M. B. & HUBERMAN, A. M. (1994) *Qualitative Data Analysis: an ExpandedSourcebook.* Thousand Oaks, Calif: Sage

MUMBA, F., CARVER, J., CHABALENGULA, V.M., HUNTER, W.J.F. (2008). Chemistry teaching fellows' understanding of the nature of scientific theories. *Journal of Baltic Science Education, 8*(1), 15-21.

ÖZCAN, I. (2011). *Bilimin doğası inanışlarına yönelik bir ölçeğin geliştirilmesi ve fen bilgisi öğretmen adaylarının bilimin doğası inanışlarının tespiti.* Yayınlanmamı Yüksek Lisans Tezi, Marmara Üniversitesi, Eğitim Bilimleri Enstitüsü, İstanbul

ÖZDEM, Y., CAVAŞ, P., CAVAŞ, B., ÇAKIROĞLU, J., ERTEPINAR, H. (2010). An investigation of elementary students' scientific literacy levels. *Journal of Baltic Science Education*, *9*(1), 6-19.

PEÑA, A., PACO, O. (2004). Attitudes and views of medical students towards science and pseudoscience. *Med Educ Online* [serial online], *9*(4), 1-7. Retrieved from http://www.med-ed-online.org. (15.01.2010)

RUBBA, P. A. & HARKNESS, W. L. (1993). Examination of preservice and in-service secondary science teachers' beliefs about science-technology-society interactions. *Science Education, 77*(4), 407-431.

RYDER, J., LEACH, J., & DRİVER, R. (1999). Undergraduate science students' images of science. *Journal of Research in Science Teaching, 36*(2), 201– 219.

SAGAN, C. (2010). *Karanlık bir dünyada bilimin mum ışığı* (M.Göktepeli, Çev).Ankara: TÜBİTAK Popüler Bilim Kitapları

SETTLAGE, J., SOUTHERLAND, S.A. (2012). *Teaching science to every child: Using culture as a starting point*. Newyork & London: Routledge

SHAPİRA, B.L. (1989). What children bring to light: Giving high status to learners' views and actions in science, *Science Education*, *73*, 711–733.

SHİANG-YAO, L. & LEDERMAN, N. G. (2007). Exploring prospective teachers' worldviews and conceptions of nature of science. *International Journal of Science Education, 29*(10), 1281–1307.

SMİTH, M. U. & SCHARMANN, L. C. (1999). Defining versus describing the nature of science: A pragmatic analysis for classroom teachers and science educators. *Science Education, 83*, 493–509.

SURMELİ, H., SAKA, M. (2011). Paranormal beliefs of preservice teachers'. *Procedia - Social and Behavioral Sciences*, *15*, 1385-1390

TATAR, E., KARAKUYU, Y., TÜYSÜZ, C. (2011). Sınıf öğretmeni adaylarının bilimin doğası kavramları: Teori, yasa ve hipotez. *Mustafa Kemal Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 8*(15), 363-370.

THAGARD, P. (2011). Evolution, creation and the philosophy of science. In R.S.Taylor & M.Ferrari (Eds.), *Epistemology and science education: Understanding the evolution vs intelligent design controversy*(pp. 20-37). Newyork & London: Routledge.

TURGUT, H. (2009). Fen bilgisi öğretmen adaylarının bilimsel bilgi ve yöntem algıları. *Türk Eğitim Bilimleri Dergisi, 7*(1), 165-184.

USLU, F. (2011). Blimselliğin kriteri ve sınırları problemi-bilim, bilim olmayan ve sahte bilim. *Hitit Üniversitesi İlahiyat Fakültesi Dergisi*, *10*(19), 5-35.

WYNN, C.M & WİGGİNS, A.W. (2002). *Yanlış yönde kuantum sıçramalar* (A.Kence, Çev). Ankara: TÜBİTAK Popüler Bilim Kitapları.

YILDIRIM, C. (2008). *Bilimsel düşünme yöntemi*. İmge Kitabevi Yayınları.