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Öğretmen Adaylarının Bilimin Doğası Hakkındaki Görüşlerinin İncelenmesi
Exploration of Preservice Science Teachers' Nature of Science Understandings

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Öz

Mevcut çalışma Fen Bilgisi Öğretmen adaylarının bilimin doğası ile ilgili görüşlerini araştırmayı amaçlamaktadır. Çalışmada, nitel araştırma yöntemlerinden fenomenoloji araştırma yöntemi kullanılmıştır. 15 (1 erkek, 14 kadın) üçüncü sınıf fen bilgisi öğretmen adayı çalışmaya katılmıştır. Fen bilgisi öğretmen adaylarının bilimin doğası görüşleri Abd-El Khalick (1998) tarafından geliştirilen VNOS-B anketi kullanılarak incelenmiştir. Bu görüşler, naif, geçişken, ve bilgili olmak üzere üç kategoride sınıflandırılmıştır. Bulgular öğretmen adaylarının büyük bir kısmının bilimin deneysel doğasına yönelik, öznel, değişebilir, çıkarımsal, ve sosyokültürel değerlerden etkilendiği konusunda bilgili oldukları ancak teori- kanun ilişkisi konusunda naif görüşe sahip olduklarını göstermektedir. Genel olarak fen bilgisi öğretmen adaylarının bilimin doğası hakkında yeterli bilgiye sahip oldukları söylenilebilir.
Anahtar sözcükler: bilimin doğası, öğretmen adayları, bilim okuryazarlığı

Abstract

Present study aims to explore Preservice Science Teachers (PST) Nature of Science (NOS) views. Qualitative research methodology guided the present study. The phenomenological approach was used to identify PSTs' NOS understandings. Fifteen (1 male, 14 female) junior students studying in public university participated to the study. The NOS views were tested through the administration of VNOS-B survey developed by Abd-El Khalick et al., (1998). PSTs' views were categorized as naïve, transitional, and informed. Results showed that most of the PSTs have informed views for the empirical, subjective, tentative, creative, inferential, and social cultural aspects of NOS. There was one exception: for the theory-laden aspects, most of the PSTs hold naïve views. It can be concluded that the majority of the PSTs who participated in this study hold informed views about NOS.
Keywords: Nature of science, Preservice science teachers, Scientific literacy

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Introduction

Scientific literacy has been an important aspect in science education for more than six decades. Students' active and social engagement in real life issues promotes scientific literacy which is a long-standing goal of science education (Fowler, Zeidler, & Sadler, 2009). The literacy, especially scientific literacy, has broad and complex meaning so that there is no consensus on definition of the term (Baybee, 1997). However general characteristics of a scientifically literate person can give a hint to understand the term. Scientifically literate person understands science and its application to everyday life, can able to think scientifically and critically. Moreover, s/he has knowledge of the risk and benefits of science (Norris & Philips, 2003). In addition, scientifically literate person can able to make informed decisions and choices which is needed for enhancing future citizens' intellectual capabilities and knowledge (Tyler, 2007). Thus, utmost importance has been given to the term scientific literacy in science education. Researchers seek to find alternative ways to enhance citizens' scientific literacy.

NOS has been highlighted as critical component that prepare students as responsible citizens (Abd-El-Khalick, & Lederman, 2000; Halbrook & Rannikmae, 2007) and has become the central means to enhance the public's scientific literacy (Park et al., 2014). The strategic role of scientific knowledge in daily activities forced science educators to address the characteristic of scientific knowledge and the NOS issues through the school years. Science education community across the world aimed to improve not only students, but also teachers and teacher candidates' views about NOS believing that education should help individuals to adapt modern life, to use scientific knowledge in daily life activities (American Association for the Advancement of Science [AAAS], 1993; National Research council [NRC], 2000, MONE, 2005).

Many science educators (Sadler, Chambers & Zeidler, 2004; Zeidler, Walker, Ackett, & Simmons, 2002) reached a similar conclusion that is "an individual's understanding of NOS inescapably changes his response to situations engaging science. If so, there should be more investigations exploring or enhancing individuals' NOS understandings (Abd-El-Khalick, 2003; Bell & Lederman, 2003). Teachers' and preservice teachers' NOS understandings are thought to have central role from past (Lederman & Zeidler, 1987; Lederman, 1992) to present (Akerson, Pongsanon, Rogers, Carter & Galindo, 2017; Khishfe, 2017) on students' NOS understandings. Previous literature have so many investigations that assert teachers influence their students' NOS understandings (Yang, Han, Choi, Oh & Cho, 2005; Lucas & Roth, 1996; Park et al., 2014; Lederman, 1999) and suggest that teachers of all grade levels should help students develop informed understandings of NOS (Akerson et al., 2017). Teachers are expected to transfer their informed views into their teaching practices (e.g., Akerson & Volrich, 2006).

Previous literature, both international and national level, have many examples of investigating preservice teachers' NOS understanding. For instance; Bektas, Ekiz, Tüysüz, Kutucu, Tarkin, Uzuntiryaki-Kondakci (2013) explored pre-service chemistry teachers' pedagogical content knowledge of the nature of science (NOS) in the content of the particle nature of matter. They highlighted the importance of development of pre-service teachers' understanding of NOS as it is crucial to be able to teach NOS. Teacher education programs should consider developing NOS views of pre-service teachers (Bektas et. al., 2013). Moreover, Bilen (2012) investigated pre-service science teachers' views about nature of science and to look at whether these views were traditional or contemporary. Researcher emphasized the link between scientific literacy and nature of science understanding. It is necessary to increase NOS course hours during undergraduate education to develop PSTs' NOS understandings and to design these courses as they catch PSTs' attentions. (Bilen, 2012). Akerson and Volrich (2006) focused on one preservice teacher's (Morgan) efforts to emphasize NOS aspects in her internship classroom. They highlighted that teachers cannot teach what they do not understand, thus it is important to explore preservice teachers' NOS understandings during undergraduate education to have teachers who develops intention to teach NOS.

Teachers' adequate understanding of NOS is assumed as a prerequisite to teach NOS sufficiently. However, significant amount of research points out that teachers themselves have inadequate understanding of NOS (e.g., Lederman, 2007). If this is the case, exploring teachers' NOS views and targeting to enhance those understandings are noteworthy. The primary aim of the current study is to identify the Preservice Science Teachers' (PSTs) NOS views and to give some recommendations to science educators. To reach this aim, following research question guided the present study;

RQ-1: What are PSTs' conceptions of NOS?

Methodology

Qualitative research methodology guided the present study. The phenomenological approach was used to identify PSTs' NOS understandings. Phenomenology asks for the very nature of a phenomenon aims at gaining a deeper understanding of the nature or meaning of everyday experiences (Patton, 2002). Thus, present study used phenomenology to explore PSTs' NOS views.

Participants

The researchers used purposive sampling in order to collect information rich data. This sampling is preferred by the researchers who want to get the best information about a specific situation (Patton, 1990). Although the aim of the study was to explore PSTs' NOS views junior grade students who were taking history of science and NOS course were thought to provide the best information. None of the researchers were the course instructor and none of them was teaching any course to the participants when the data was collected. Researchers aimed to explore PSTs' NOS views at the very end of the semester when they just completed the history of science and NOS courses. There were fifty PSTs who are attending junior class (meets the purposive sampling criteria) when this research was planned. They were informed about the data collection procedure, they were announced that participants are required to respond VNOS-B open ended questionnaire in written format which took 20 to 30 minutes. Researcher ensured that the confidentiality of data would be protected, and students' names would not be revealed anywhere. They were asked to write pseudonyms on the paper instead of their real names. 15 (1 male, 14 female) junior students studying in public university participated to the study. Students' ages ranged between 18 and 20. Participants in this study have completed science education and pedagogical courses in addition to other subject matter courses such as; physics, chemistry, biology, technology, history, and English at the time this study was conducted.

Data Collection Tool

NOS instruments VNOS-B

Views on Nature of Science-B (VNOS-B, (Abd-El-Khalick et al., 1998) was used as a major tool to assess PSTs' NOS understandings. VNOS-B aims to elucidate students' views about several aspects of NOS. In present study, PSTs' responded to this open-ended VNOS-B questionnaire designed to assess their conceptions of the NOS conceptions.

Data Analysis Procedure

Inductive approach for qualitative data analyses were used to provide themes present in the PSTs responses about NOS. Categories were predetermined in accordance with experts in the field. All of the statements in raw data were transcribed verbatim and coded. Prior to scoring the manuals, two researchers met to discuss the scoring of the VNOS-B. Lederman et al. (2002)'s study was used as analysis framework (see Appendix A) where they explicitly informed the reader about scoring VNOS-B and gave particular examples for each NOS aspect. PSTs written responses to VNOS-B questionnaire were coded by two researchers who had similar NOS background. Both researchers were working as an assistant professor in science education and had been teaching the NOS course for at least two semesters. It is necessary to establish inter rater agreement in order to conduct reliable analysis. Therefore, two researchers analyzed the selected transcribes independently by using Appendix A as coding sheet and then compared their analyses. The discrepant codes were discussed and researcher reached consensus on each code (naïve, transitional and informed). Then, all papers were assessed together.

Results

Present study aimed to explore PSTs' NOS views. The document analysis revealed that PSTs' views with respect to each NOS aspect differed. Thus, PSTs' views in each aspect were presented independently. Each aspect was discussed by presenting the frequency table of informed, transitional and naïve views below.

Empirical nature of science

The document analysis revealed that the PSTs had different views on the empirical NOS aspect.

Table 1. PSTs' Sample Excerpt Related to Empirical Aspect of NOS.

NOS Views	Sample Excerpt	Researcher Rationale	Freq.	%
Naive	Science links the nature and human; I mean it helps people to adapt and to understand the natural world. Scientist observe the nature and find out general facts, for example, Newton found gravity; he observed and found a general fact [free fall]. An apple fell, and he found the fact, but you know the fact is over there (PST-1)	Fails to recognize reliance on evidence to support scientific claims. She thinks that Science is concerned with facts. We use observed facts to prove that theories are true	4	26
Transitional	In science, it is necessary to do research to conduct an experiment and to pose scientific evidence. There is consensus on [scientific] knowledge. (PST-7)	She refers to data and testing. She emphasizes role of consensus.	2	13
Informed	.. actually, science is a journey to the nature, we have to understand the nature, the planet in order to survive. First of all, science requires experiment and observation; there should be scientific claims and evidence. (PST-9)	She understands that scientific claims must base on empirical evidence.	9	61

Table 1 illustrates that, 26% of the PSTs showed naïve understanding of empirical NOS, 13% of them showed transitional views on empirical NOS, and the remaining 61% of them showed informed views.

Theory and law

Although there were some informed views on this aspect (33%), most of the PSTs (40%) posited naïve views about theory and law. Four of the PSTs (27%) had transitional views about theory and law. A few of the PSTs can explain the differences between theory and law, and their importance for scientific knowledge.

Table 2. PSTs' Sample Excerpts Related to Theory and Law Aspect of NOS

NOS Views	Sample Excerpt	Researcher Rationale	Freq.	%
Naïve	..Laws are confirmed by everyone and never change. For example, we feel gravity; we see it during free fall. ...if my results do not overlap with the theory, I suspect, the theory can be wrong, you know if it were general truth, it would become law. (PST-5)	Holds a hierarchical view between theory and law. She believes that theory become laws (which is not true.)	6	40
Transitional	It [law] is the consensus about an issue. It might be change over time, I don't think that the laws are general truth that can never be criticized or change. …the theory should be wrong and need to be revised. (PST-11)	She knows the difference between theory and law. However, she is unable to articulate clear definitions and provide examples.	4	27
Informed	..The law must be confirmed and broadly agreed. But the scientific knowledge develop day by day, on each day, something has changed, scientist criticizes existing knowledge, so like everything, the laws also can be triggered and can be change. We all know gravity law, but there are some alternative theories to this law. We see that some theories can criticize a law. (PST-3)	She recognizes theories and laws are end products of science and distinct from one another. Understand that laws are primarily descriptive, and theories may be use to explain laws.	5	33

In general, PSTs who have naïve understanding of theory and law aspect of NOS hold a hierarchical view of the function and relation of these two concepts. They assumed that theories became law if they are proven. PSTs who have transitional views recognized these two concepts are different than each other, but they could not provide a clear definition and good example. On the other hand, PSTs who have informed views recognized that theory and laws are end product of science.

Subjectivity

Of the 15 PSTs, 33% showed naïve understanding of subjective NOS, 20% showed transitional views, and the remaining 47% showed informed views. Table 3 demonstrating the summary of the descriptions of each view on subjective aspects of NOS as well as corresponding frequencies (freq.) and percentages (%) of each category (naïve, transitional, and informed). Following the table, detailed information about the meanings of each views and exemplars fitting each NOS view is given.

Table 3. PSTs' Sample Excerpts Related to Subjectivity Aspect of NOS

NOS Views	Excerpt	Researcher Rationale	Freq.	%
Naïve	Objectivity is necessary. If they [scientist] are not, they cannot look at the problem from multiple perspective, they just examine what they want to examine, which prevents from reaching true conclusion. (PST-7)	The student views scientists as objective and value free	5	33
Transitional	Objectivity is necessary while trying to pose a research question, but it is difficult to be objective. Because, you know we are human-beings. We have a bias and interpret the results depending on those biases. Thus, I do not think objectivity is possible. (PST-5)	She thinks that the objectivity is necessary. But she understands that to be objective is difficult so objectivity can play a role, but she assumes that it is unethical or bias.	3	20
Informed	I think, as we all human; objectivity is impossible. I cannot leave my personal values out of the laboratory and behave as if I am an objective person and have no bias or background about the issue. (PST-9)	She recognizes that, human subjectivity is inherent in scientific work. Subjectivity guides future work, and she understands that this is acceptable.	7	47

In general, PSTs who have naïve understanding of subjective NOS thought that scientists are value free and objective. The PSTs claimed that there might be different views on same issue but it cannot be determined which explanation is right. PSTs who have transitional views, recognized subjectivity can play a role in science and scientific development, but they assumed subjectivity as bias or unethical issue. On the other hand, PSTs who have informed views stated that human subjectivity is inherited in all scientific work. They recognized that today's explanations guide future works.

Tentativeness

Table 4 demonstrates the summary of the descriptions of each view on tentative aspect of NOS as well as corresponding frequencies (freq.) and percentages (%) of each category (naïve, transitional, and informed).

Table 4. PSTs' Sample Excerpts Related to Tentativeness Aspect of NOS

NOS Views	Excerpt	Researcher Rationale	Freq.	%
Naive	The laws are always valid. If it became law, it means that all the counter arguments are disproved, and then that law is valid across the world, never changes. (PST-6)	Naïve people assume that the scientific knowledge is absolute, proven, and unchanging.	4	27
Transitional	… each day, something has change, some new evidence can change todays truth. …the laws are in different category; they [laws] depends on well confirmed scientific knowledge. [they] cannot be changed. (PST-10)	Transitional students recognize that the scientific knowledge can change but still, they may emphasize durability over tentativeness. They state that scientific laws are unlikely to change.	2	13
Informed	Scientific knowledge can change; I believe it develops over time thanks to its dynamic nature. (PST-2)	Informed students understand that while it is durable, all scientific knowledge subject to change with new evidence.	9	60

In general, PSTs who have naïve understanding of tentative aspect of NOS viewed science as an accumulation of facts those are proven and unchanging. PSTs who have transitional views, recognized the scientific knowledge can change however these PSTs prefers durability over tentativeness.

Creativity and imagination

The PSTs who believe that creativity and imagination are vital for science (60%), revealed informed views about science. On the contrary, the remaining PSTs (40%) think that there is a stepwise procedure in science, showed naïve views about the creativity and imagination aspect of NOS. Table 5 demonstrating the summary of the descriptions of each view on creativity and imagination aspect of NOS as well as corresponding frequencies (freq.) and percentages (%) of each category (naïve, and informed). For this aspect, there were only naïve and informed PSTs therefore the table presents excerpts belongs two categories.

In general, PSTs who have naïve understanding of creativity and imagination aspect of NOS viewed science as a procedural issue. On the other hand, PSTs who have informed views stated that creativity is necessary for all steps of science. They recognized that theories laws ideas are all created and they realized that there is no single scientific method that scientists use to construct theories and explanations.

Table 5. PSTs' Sample Excerpts Related to Creativity and Imagination Aspect of NOS

NOS Views	Excerpt	Researcher Rationale	Freq.	%
Naive	In order to reach facts, scientists should make some experiments rather than use imagination. If there is a gap between the experiment and data collection, scientists understand that they should try other ways to support their ideas. (PST-11)	Naïve people view science as procedural rather than creative. In this statement, the students emphasize the importance of experimentation.	6	40
Transitional	-	-	0	0
Informed	Yes, scientists use their imagination and creativity during and after data collection. Scientists often make only tentative hypotheses using their creativity or imagination. For example, atomic theories, there is more than one theory in order to explain the structure of the atom. When a theory is limited to explain some aspect the other may work (on the same data), scientist use their imagination to explain the phenomena. (PST-12)	Informed students consider that creativity and imagination are necessary for scientific developments.	9	60

Inferential

All of the PSTs (100%) who participated in this study, showed informed views for inferential aspect of science.
Table 6 demonstrating the descriptions of informed views of PSTs' inferential aspect of NOS. 100 % of PSTs hold informed views for 'inferential NOS aspect. Therefore, the table only includes informed views. Two PSTs statements were presented in the table.

Table 6. PSTs' Sample Excerpts Related to Inferential Aspect of NOS

NOS Views	Excerpt	Researcher Rationale	Freq.	%
Informed	The universe is so big that there is no data to show the real situation. All the astronomers are using their explanations [inferences] both Newton's laws and Einstein's relativity theory. However, both Newton and Einstein made inferences create their theories. (PST-4)	She recognizes that direct observation is not be possible for every situation.	15	100
	I believe the interpretation of astronomers is different. Even they are looking at the same universe and data, their knowledge, ideas create a difference and their inferences can diverge. (PST-2)	She understands that astronomers make some reasonable inferences.		

PSTs who have informed views about inferential aspect of NOS stated that it is not possible to observe all phenomena in science. However, they emphasized that through indirect evidence, scientist use indirect evidence to make logical interpretations.

Sociocultural effects

Of the 15 PSTs, 33% showed the transitional understanding of social-cultural aspects of NOS, while 67% showed informed views. Table 7 demonstrating the summary of the descriptions of each view on sociocultural aspects of NOS as well as corresponding frequencies (freq.) and percentages (%) of each category (naïve, transitional, and informed).

Table 7. PSTs' Sample Statements Related to Socio Cultural Aspect of NOS

NOS Views	Excerpt	Researcher Rationale	Freq.	%
Naive	-	-	0	0
Transitional	...sometimes it [science] is effected by scientists world view and the culture s/he lives in, I really could not be able to what to think about this. imm I think a scientist should be objective, does not allow his personal values effect his research. (PST-5)	This student recognizes the role of society, but she emphasizes that science should be universal.	5	33
Informed	It [science] is helpful for people to understand and to adapt the nature. Therefore, there is an interaction; I mean it is affected by our needs, our perspectives. In the end, it is human production. This explains why religious scientists avoid doing research on evaluation. (PST-11)	She views science as human endeavor, recognize that science influences society, and influenced by society.	10	67

To conclude, PSTs participated in this study have diverse views about NOS aspects. An overall frequency distribution showing PSTs' views with respect to each NOS aspect can be seen in Figure 1.

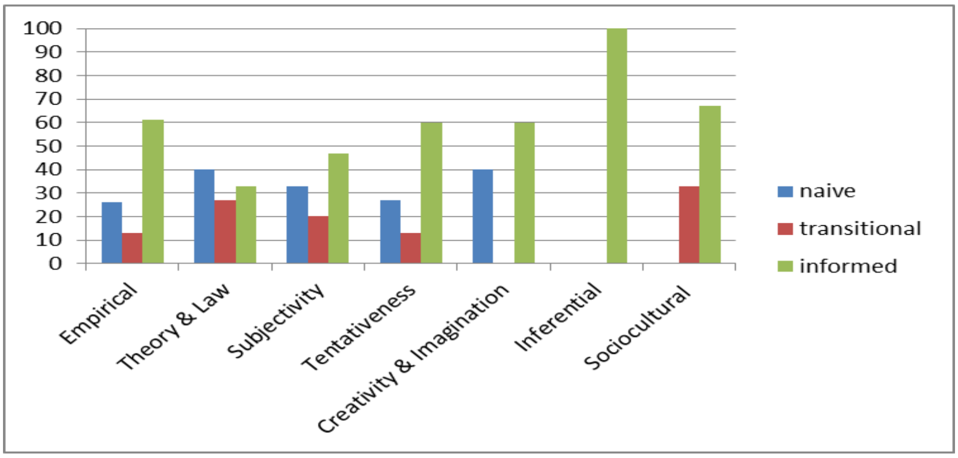

***Figure 1*. The percentages of PSTs Naïve, Transitional, and Informed views for each NOS aspect**

Discussion

In this study, we explored PSTs' views about NOS aspects. In general, pre-service science teachers held informed views with respect to most of NOS aspects including empirical, subjective, tentative, creative, inferential, and sociocultural aspects. In fact, it was a desired outcome as teachers of all grades are expected to develop students' understanding of NOS as a critical function of raising scientific literate generations (National Science Teacher Association [NSTA], 2000). Moreover, an informed understanding of NOS is expected to enable students to acquire a deeper comprehension of science content, to develop informed decision-making based on evidence as well to develop interest for studying science as a future career (Akerson et al., 2017). Supporting our finding, Akerson and Volrich (2006) reported that the PSTs who completed science teaching methods course developed an informed view of and intention to teach NOS. However, all the PSTs, in this study, did not hold informed views with respect to all NOS aspects. For instance, while all of them were informed about inferential NOS, more than half were informed with respect to empirical, sociocultural, tentativeness and creativity and imagination aspects. On the other hand, nearly half held naive and transitional views with respect to subjective NOS. Moreover, only 33% held informed views with respect to theory and law distinction. This finding is also consistent with the literature which reported that PSTs held inadequate views with respect to mentioned NOS aspects (e.g., Cetinkaya Aydin & Cakiroglu, 2017). Below, each NOS aspect was discussed.

With respect to empirical NOS, we saw that half of students believed that science explains phenomena through experiments, observations, and inferences, which imply that there is a requirement of evidence in scientific claims. Whereas there were still PSTs who hold transitional views and naïve views with respect to this aspect. This finding is consistent with Cetinkaya Aydin and Cakiroglu (2017)'s findings which reported that majority of PSTs who completed NOS course had either adequate (61.7%) and informed (23.3%) views with respect to empirical basis of NOS. On the other hand, there were still some PSTs who had inadequate views (15%).

In a similar manner, half of the PSTs recognized the subjectivity guided the scientific work of scientists. There were some PSTs who believed that scientists should be value free and objective which is accepted as naïve perspective, others believed objectivity is needed even though it is hard to achieve (transitional view). This finding is also consistent with the literature which reported that participant usually held inadequate understanding of subjective NOS (e.g., Bilican, Cakiroglu & Oztekin, 2015).

On the other hand, nearly half believed that there was a hierarchy in theory and law classification which implied that these students had naïve views in this aspect. Of course, there were PSTs who able to differentiate theories from laws but unable to articulate clear definitions of them (transitional views) and differentiate that while laws explain the relationships between observable phenomena, the theories are inferred explanations of observable phenomena. Holding naïve ideas about many NOS aspects, in fact, is an expected result compared to previous studies (e.g., Abd-el-Khalick, 2006; Matkins & Bell, 2007; Cetinkaya Aydin & Cakiroglu, 2017; Dogan & Abd-El-Khalick, 2008). Studying with a representative national sample from Turkey, Dogan and Abd-El-Khalick (2008) reported that most of participating students (82.6%) and teachers (77%) had naïve views with respect to theory-law distinction.

More than half believed that the scientific knowledge is subject to change even it is durable, there were still some PSTs who believed scientific knowledge is absolute, proven and unchangeable (naïve view). In a similar manner, all the PSTs participating Matkins and Bell's (2007) study expressed that scientific knowledge is absolute and proven before explicit NOS instruction. The explicit NOS instruction caused a shift in participants' ideas about tentativeness aspect even there were still some PSTs who still hold absolute views of scientific knowledge. Similar findings were also revealed in Bilican et al.'s (2015) study.

With respect to creativity and imagination, more than half recognized the necessary role of creativity and imagination in scientific knowledge. However, nearly half believed that procedural knowledge rather than creativity is needed. Even our study revealed that our participants hold relatively informed views, the available literature report vice versa (e.g., Akerson, Weiland, Pongsanon, & Nargund Joshi, 2014; Dogan & Abd-El-Khalick, 2008). The

PSTs did not discuss, or provide feedback regarding the NOS aspects of scientific creativity, the social-cultural influences on science, and the relationship between theory and law.

With respect to sociocultural aspect, most PSTs acknowledged that science is human endeavor and influenced by society itself even though there were PSTs who thought that science should be universal apart from cultural and social affects. This finding is consistent with Matkins and Bell's (2007) findings which reported explicit NOS instruction was successful in increasing the number of PSTs (27%) who mentioned that scientific knowledge is influenced by the society and culture. on the other hand, there were still some PSTs who did ignore the role of society and culture in scientific enterprise.

In fact, all the PSTs acknowledged the inferences cannot be accessed or directly observed but sensed though the effects of direct observations. We can conclude that PSTs had diverse views about NOS aspects. Holding informed and naïve views of NOS may be related with the PSTs' courses in undergraduate education including subject matter (general Physics, Biology, and Chemistry) as well as pedagogical courses including NOS , History of science and Science Laboratories. In her study, Khishfe (2012) reported that instruction focusing on NOS aspects enhanced students' understanding of NOS. Specifically nearly half of the participants referenced NOS aspects including empirical nature, tentativeness and subjectivity in their explanations. After NOS instruction, students informed views with respect to five NOS aspects (tentativeness, empirical based, inferential, creativeness and imagination and subjectivity in NOS) enhanced. Even though we did not specifically conduct an intervention about the effectiveness of NOS instruction, the history of science course that PSTs had taken may influence PSTs' ideas about NOS. For instance, the literature suggest that history of science course could promote understanding of NOS (e.g., Rudge & Howe, 2009). Thus, the authors concluded that instruction focusing on NOS would be an effective tool with respect to introducing different viewpoints in science courses. In our case, it was important to determine the PSTs' views about different NOS aspects as because teachers' conceptions reflect upon their classroom practices (Bilican, Ozdem-Yilmaz & Oztekin, 2014; Nott & Wellington, 1996). Thus, if teachers graduate with informed views about NOS aspects, they would reflect their informed views into science classes. Otherwise holding naïve and transitional views of NOS may also result in their students' holding naïve ideas of NOS. In fact, previous studies also reported that teacher held naïve ideas about NOS (e.g., Abd-El-Khalick, 2005; Akerson & Donnely, 2010; Bell, Matkins, & Gansneder, 2011; Bilican et al., 2015). This could be overcome by using explicit reflective NOS instruction as proposed by Abd-El-Khalick and Lederman (2000). Actually, this approach was reported to enhance PSTs' conceptions of NOS (Abd-El-Khalick & Lederman, 2000; Abd-El-Khalick, 2005; Bell, 2001; Bartholomew, Osborne, & Ratcliffe, 2004; Khishfe & Abd- El-Khalick, 2002; Matkins & Bell, 2007; McComas, Almazroa & Clough, 1998). Even teaching NOS by using explicit reflective approach was proposed as an effective way by aforementioned studies, this was not sufficient as itself.

In our study, we found that most of PSTs held informed views with respect to empirical, subjective, inferential, creative and sociocultural aspects of NOS even there were some PSTs holding naïve and transitional views. Contrasting this finding, in a case study, exploring the effectiveness of contextualized NOS instruction, Bilican et al. (2015) found that PSTs' held inadequate views with respect to tentative, empirical, inferential, creative, social-cultural, theory and low aspects of NOS before instruction. In another study, Bilican et al. (2014) found similar findings with respect to NOS aspects before NOS instruction. Even contextualized NOS instruction in both studies, PSTs still held some naïve ideas with respect to NOS aspects. In a similar vein, Schwartz (2007) reached the same conclusion. Despite the strategies used in NOS instruction (repeated examples, peer conversations, whole class discussion, and reflective writings), she concluded that some participants held their initial conceptions. She indicated that even the participants modified most NOS aspects including tentativeness, they still held their initial views with respect to tentativeness after NOS instruction. In our case, we also came up the same conclusion. Our participants completed many courses including NOS, , science methods course and pedagogical courses, they still held naïve ideas with respect to many NOS aspects including tentativeness and subjectivity. Schwartz (2007) interpreted this as it might be more difficult for some participants to change their views with respect to subjectivity because of truth judgements, broader epistemic views which hinder modification in NOS aspects or insufficient examples used during NOS instruction. We also believe that using more examples focusing on various NOS aspects might be useful in developing informed views Another explanation of holding naïve ideas about tentativeness and subjectivity is the content of science textbooks which still emphasize that science and scientists must be objective which is resulted as students' holding resistant views of subjectivity and tentativeness (Abd-El-Khalick et al., 2017). The insufficient representation of NOS aspects in the content of science textbooks was referred both in national (Irez, 2009) and international contexts (e.g., Abd-El-Khalick et al., 2017; Chiappetta & Fillman, 2007). Another possible explanation provided by Dogan and Abd-El-Khalick (2008) is that absence of systematic treatment of NOS in Turkish national science curriculum may yield students' developing naïve ideas about NOS aspects.

The Figure 1 highlighted that majority of PSTs have informed views about empirical, subjective, tentative, creative, inferential, and sociocultural aspects of NOS. Their having adequate knowledge about NOS aspects and having informed views about these aspects may contribute to their scientific literacy levels. The theory and law aspect of NOS is the only aspect that majority of PSTs hold naïve views.

The NOS views was tested through the administration of VNOS-B survey. PSTs views are categorized as naïve, transitional, and informed. For the creativity aspect, PSTs had either naïve or informed views. There were no PSTs who have transitional views for this aspect. On the other hand, for the inferential aspects of NOS, there were only two categories, either transitional or informed; the PSTs did not hold naïve views for inferential NOS aspects. In general, most of the PSTs have informed views for the empirical,- subjective, and tentative, creative, inferential, and social cultural aspects of NOS. There was one exception: for the theory-laden aspects of NOS, most of the PSTs hold naïve views. The PSTs' NOS views varied from one aspect to another aspect. Still, it can be concluded that the majority of the PSTs who participated in this study hold informed views about NOS.

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Öğretmen Adaylarının Bilimin Doğası Hakkındaki Görüşlerinin İncelenmesi

Uzun özet

Giriş

Bilimsel okuryazarlık kavramı, kapsamlı ve karmaşık bir terim olmasından dolayı tanımı konusunda fikir birliği bulunmamaktadır. Fakat bilimsel okuryazar bireylerin özellikleri, bilimsel okuryazarlık kavramını tanımlarken araştırmacılara fikir sağlayabilir. Bilimsel okuryazarlık, aynı zamanda revize edilen fen bilimleri programında da önemle vurgulanmaktadır. Bilimsel okuryazarlığı arttırmada sıklıkla vurgulanan kavramlardan biri de bilimin doğası ve boyutlarıdır. Bilimin doğası bilimin epistemolojisi, bilme yolu olarak bilim veya bilimsel bilginin gelişiminin doğasında var olan değer ve inançlar olarak tanımlanmaktadır. Bilimin doğasını bazı temel özellikleri ise bilimsel bilginin deney ve gözlem verilerine dayalı olması, teori ve kanunların birbirinden farklı olması, bilimsel bilginin elde edilmesinde öznelliğin yapılan çalışmaları etkilemesi, değişebilir fakat güvenilir olması, yaratıcılık ve hayal gücünün bilimsel bilginin gelişimine katkısı ve bilimin sosyal ve kültüre bağlı yapısıdır. Fen eğitiminin temel amaçlarından bir tanesi öğrencilere bilimin doğasının bu boyutları hakkındaki anlayışlarını geliştirmektir. Bu bağlamda öğretmenlerin ve geleceğin öğretmenleri olan öğretmen adaylarının bilimin doğası ile ilgili anlayışları ön plana çıkmaktadır. Yapılan araştırmalar öğretmenlerin, öğrencilerinin bilimin doğası anlayışlarını etkilediğini ortaya koymaktadır. Bu ancak öğretmenlerin öğretim etkinliklerine bilimin doğası boyutlarını entegre etmeleri ile mümkündür. Yapılan araştırmalar gerek Türkiye'de gerekse yurt dışında öğretmenlerin bilimin doğası anlayışlarının geliştirilmesinin önemli olduğunu vurgulamaktadır. Buradan yola çıkılarak bu araştırmada aşağıdaki araştırma sorusuna cevap aranmıştır:
Öğretmen adaylarının bilimin doğası boyutları hakkındaki görüşleri nelerdir?

Yöntem

Nitel araştırma yöntemlerinden fenemonoloji, öğretmen adaylarının bilimin doğası boyutları hakkındaki algılarını ortaya çıkarmada kullanılmıştır. Fenemonoloji, bir olgunun derinlemesine incelenmesi amacıyla kullanılmaktadır. Araştırmada, zengin bir veri elde emek için amaçlı örnekleme yönteminden yararlanılmıştır. Araştırmaya, bir devlet üniversitesinde öğrenim görmekte olan 15 fen bilgisi öğretmen adayı katılmıştır. Veri toplama aracı olarak Bilimin doğası Görüşleri Anketi [Views of Nature of Science (VNOS-B)] kullanılmıştır.

Bulgular

Araştırmaya katılan öğretmen adaylarının VNOS-B anketine verdikleri cevaplar incelendiğinde, öğretmen adaylarının bilimin doğası boyutları hakkında farklı görüşlere sahip oldukları görülmüştür. Katılımcıların tamamı bilimin çıkarımlara bağlı doğası konusunda bilgili oldukları görülürken, katılımcıların yarısından fazlasının bilimin sosyokültürel yönü konusunda yani bilimin toplumu ve toplumun da bilimi etkilediği konusunda bilgili düzeyde oldukları görülmüştür (%67). Benzer şekilde, katılımcılar bilimsel gelişmeler için yaratıcılık ve hayal gücünün gerekliliği konusunda bilgili olduğu görülürken (%60), katılımcıların aynı zamanda bilimsel bilginin sürekli olduğu ancak bilginin yeni bilimsel kanıtlar ile birlikte değişebilirliği konusunda bilgili düzeyde oldukları belirlenmiştir (%60). Aynı zamanda, katılımcıların %61'i, bilimsel iddiaların deneysel verilerle desteklenmesinin gerekliliği konusunda bilgili düzeyde oldukları görülmüştür. Buna rağmen katılımcıların bir kısmının ise (%26) bu boyutta naif görüşe sahip oldukları ve bilimsel iddiaların kanıtlanmasında deneysel verilere dayalı olmanın öneminin farkında olmadıkları görülmüştür. Diğer gözlemlenen önemli bir husus ise, katılımcıların sadece %33'ü, bilimsel teori ve kanunlar arasındaki ilişkiyi belirleyebilmekte ve ikisini ayırt edebilmektedir. Bu katılımcılar kanunların öncelikle betimsel olduğunu ve teorilerin ise kanunları açıklamada kullanabileceğinin farkındadırlar. Bu boyutta katılımcıların %40'ının ise naif görüşe sahip oldukları yani bilimsel teori ve kanunlar arasında hiyerarşik bir ilişki olduğuna dair inançlarının bulunduğu ve teorilerin kanunlara dönüşebileceğini ifade ettikleri görülmüştür. Katılımcılardan bazılarının bilimsel bilginin elde edilmesinde öznelliğin yapılan çalışmaları etkilemesi boyutunda naif görüşe sahip oldukları (%33) ve bu katılımcıların bilim insanlarını nesnel ve değerlerden bağımsız olarak nitelendirdikleri belirlenmiştir. Katılımcıların %47'si ise bilimsel bilginin doğasında insanın öznel yapısının olduğu konusunda bilgili düzeyde olduğu görülmüştür. Genel olarak bu sonuçlar, katılımcıların bilimin deneysel, değişebilir ve çıkarımlara bağlı aynı zamanda yaratıcılık ve hayal gücünün bilimsel bilginin üretilmesi gerekliliği ve bilimsel bilginin elde edilmesinde öznelliğin yapılan çalışmaları etkilemesi boyutlarında bilgili oldukları ancak teori ve kanunların arasındaki ilişkiyi ayırt etmede zorlandıkları ve önemli bir kısmının bilimsel teori ve kanunlar arasında hiyerarşik bir ilişki bulunduğuna dair naif bir görüşe sahip olduğu ya da bilimsel teori ve kanunların farkını bilmelerine rağmen bunu ifade edecek tanım ve örnekler bulamadıkları yani geçişken görüşlere sahip oldukları görülmüştür.

Tartışma

Bu araştırmada elde edilen bulgular, ilgili alan yazında rapor edilen bulgularla paralellik göstermektedir. Önceki araştırmalarda da öğretim yöntemleri dersini tamamlayan öğretmen adaylarının bilimin doğası boyutları konusunda bilgili düzeyde olduklarını ve bu boyutları derslerine entegre etmek istedikleri ile ilgili çalışmalara rastlanmaktadır. Benzer şekilde temel alan dersler, eğitim dersleri ve bilimin doğası ile ilgili lisans dersini tamamlayan öğretmen adaylarının bilimin doğası boyutlarında bilgili oldukları ile ilgili çalışmalar da görülmektedir. Bu çalışmada da öğretmen adaylarının özel öğretim yöntemleri, bilimin doğası ve tarihi gibi dersleri tamamladıkları üçüncü yıl sonunda VNOS-B anketi uygulanmış yani öğretmen adayları bu dersleri tamamladıklarında bilimin doğasının birçok boyutu hakkında bilgili düzeyde fikir sahibi olmuşlardır. Bununla birlikte, bilimin doğası boyutları hakkında geçişken ve naif görüşlere sahip öğretmen adayları da bulunmaktadır. Bu da ilgili alan yazında sıklıkla vurgulanmıştır. Bu çalışmada ise sadece bilimsel teori ve kanunlar arasındaki ilişkiler boyutunda öğrencilerin önemli bir kısmının naif görüşlere sahip olduğu görülmüştür. Sonuç olarak, bu çalışmaya katılan fen bilimleri öğretmen adaylarının bilimin doğası boyutlarının pek çoğunda bilgili düzeyde oldukları görülmüştür.

Appendix A: Analysis Framework adapted from Lederman et al. (2002)

Dimension	Question	Naïve	Informed
Empirical NOS	1, 4	*Naive participants express a belief in an empirical basis for scientific knowledge. *indicates that scientific knowledge is based solely on empirical evidence, which in their view makes science an objective endeavor.	*Scientific knowledge as based on natural phenomena, evidence, data, and observation. *Science's reliance on empirical data and reason, in contrast to art's focus on aesthetics and religion's reliance on faith and revealed truth.
Theory and Law	1, 3	*Scientific theories become laws when proven through repeated testing * Laws were proven true and theories were tentative, either because not enough data are available or because scientists are unable to design experiments or apparatus to test theories adequately.	*Scientific theories and laws as distinct but equally valid forms of scientific knowledge. *Thus, the misconception of a hierarchical relationship between theories and laws was nonexistent.
Subjectivity	7	* Cannot be able to understand differences in data interpretation * Believes that Science is objective and subjectivity, although a factor of human nature, is to be avoided in science.	* Can understand differences in data interpretation * Science is necessarily a mixture of objective and subjective components
Tentative	1,3	*Believes that laws were proven true and theories were tentative, either because not enough data are available or because scientists are unable to design experiments or apparatus to test theories adequately.	*Believes all forms of scientific knowledge are tentative.
Creativity and Imagination	4, 5	*Expresses a belief in a single scientific method. For naive people, most creativity in science occurs during conjecturing and before the scientific method is employed. *After that, the scientific method is used to determine whether the scientist's conjectures were correct.	*Participants viewed creativity in science in terms of resourcefulness in carrying out experiments and in inventiveness in interpreting data and coming up with inferences and theories.
Inferential	2	*Believes that atomic models have been developed through direct observation.	*Rejects the notion that scientists obtained their understandings of atoms through direct observations and ascribed a role for indirect evidence and inference in the construction of atomic models.
Social cultural embededness	7	* Believes that Science is about the facts and could not be influenced by cultures andsociety. Atoms are atoms here in the U.S. and are still atoms in Russia.	* Relates to the influence of societal factors, such as politics, economics, and religion, which affect the kind of science that is done *Such influence is mediated by various factors, including funding for science, and gender and racial issues