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Pre- service Science Teachers' Conceptions of Scientific Method

Fen Bilgisi Öğretmen Adaylarının Bilimsel Yöntem Algıları

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Abstract
Pre-service teachers' views about scientific method are important because their views affect what they teach and do in their future classrooms. The main aim of this study was to investigate 346 pre-service science teachers' conceptions about scientific method. Moreover the context dependence of these conceptions was examined by an investigator developed survey in conjunction with follow- up interviews. Analysis of the data revealed that participants' conceptions of scientific method can be categorized as (i) A is A, (ii) making experiment/ observation, (iii) predetermined steps, (iv) method used by scientific community, and (v) contemporary view. 44% of the participants supported existence of a single scientific method. Further, more than half of the participants believed that the way of getting reliable knowledge in physics, chemistry and biology are different. This research emphasizes the importance of considering pre-service teachers 'conceptions of scientific method as an important component of NOS. The major implication of this work for developing the concepts of method of science in the science classroom is the need to consider the pre-service science teachers' conceptions.

Keywords: nature of science, scientific method, pre-service teachers

Öz
Öğretmen adaylarının bilimsel yöntem hakkındaki görüşleri onların ileriki meslek hayatlarında neyi öğreteceklerini belirlemesi açısından son derece önemlidir. Bu çalışmanın amacı 346 öğretmen adayının bilimsel yöntem hakkındaki görüşlerini incelemek ve bu görüşlerin çalışılan alana bağlı olup olmadığını belirlemektir. Çalışmanın verileri araştırmacı tarafından geliştirilen 3 adet açık uçlu sorudan oluşan bir anket ve görüşmeler yoluyla toplanmıştır. Verilerin analizi sonucunda öğrenmen adaylarını bilimsel yöntem hakkındaki görüşleri "A, A'dır", "deney/gözlem yapmak", "önceden belirlenmiş basamaklar", "bilim komitesi tarafından kullanılan yöntemler " ve "çağdaş görüş" olmak üzere 5 kategoride açıklanmıştır. Katılımcıların %44'ünün tek bir bilimsel yöntemin varlığını kabul ettikleri görülmektedir. Ayrıca katılımcıların yarısından fazlası fizik, biyoloji ve kimya alanında bilimsel bilgi elde etmenin yönteminin farklı olduğunu belirtmiştir.Bu çalışma öğretmen adaylarının bilimin doğasının bir bileşeni olan bilimsel yöntem hakkındaki görüşlerini araştırmanın ve geliştirmenin önemini ve gerekliliğini ortaya koymuştur.

Anahtar Sözcükler: bilimin doğası, bilimsel yöntem, öğretmen adayları

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Introduction

Nature of science is a very broad term used to explain what science is, how science functions, what the role of society is in scientific enterprise, and how scientific community operates (McComas, Clough, & Almazroa, 1998). According to Lederman (2007) NOS is "the epistemology of science, science as a way of knowing, or the values and beliefs inherent to scientific knowledge and its development" (p.833). Throughout the paper the term NOS was used in compatible with the Lederman's definition. Although there is a disagreement among philosophers, historians and science educators on the definition of NOS (Alters, 1997), they agreed on the characteristics of NOS at K-12 level (Abd- El- Khalick, 2004).

Many researchers emphasized the weight of understanding in NOS as an important component of scientific literacy. It was 1960 that NOS was determined as one of the major aims of science teaching by the National Society for the Study of Education. Given the importance of NOS understanding, the assessment of students', teachers' and scientists' conceptions of NOS has been a main point for science education research over the years. Without any doubt, there is plenty of evidence for students' and teachers' misunderstanding about the NOS issues (Walls, 2012; Akerson & Donnelly, 2010; Meyling, 1997; Ryan and Aikenhead, 1992). McComas (1998) defined misconceptions in science and named them as "myths of science". According to him lack of philosophy of science content in teacher education programs, inefficacy of these programs in providing real science experiences for pre-service science teachers and textbooks are some of the main sources of the misconceptions.

In the literature pre-service science teachers' conceptions of NOS is well documented. The argument guiding these studies was that teachers need to understand NOS in order to model students by their behaviors and attitudes (Buaraphan, 2011; Craven, Hand, & Prain, 2002; Murcia and Schibeci, 1999). Reviewing the researches on pre-service teachers' conceptions on NOS is beyond the scope of this research; however it is important to note that investigations by many researchers revealed similar results indicating that pre-service teachers have a traditional view of NOS.

Pre-service teachers' views of scientific method

Pre-service teachers generally believed that scientific method is an orderly stepwise procedure that scientists should follow in order to reach valid scientific knowledge and in order to be successful scientists the steps of scientific method are needed to be followed (Haidar, 1997; Turgut, 2009; Murcia & Schibeci, 1999; Palmquist & Finley, 1997). Buaraphan (2011) used myths of science questionnaire (MOSQ) to investigate pre-service physics teachers conceptions of NOS concerning 4 main aspects; scientific knowledge, scientific method, scientist work and scientific enterprise. According to this study, two-thirds of the participants held on uninformed conception that scientific method is a fixed step- by-step process. In their study with 73 pre-

service primary teachers, Murcia and Schibeci (1999) found similar results. By using open ended and true- false questions they analyzed pre-service teachers' views of NOS and they argued that participants had a naïve and unclear understanding of scientific method.Turgut (2009) investigated prospective science teachers' conceptions about scientific knowledge and scientific method. He administered 4 open ended questions to 70 pre-service teachers and conducted interviews with ten of them. In order to probe participants' conceptions about scientific method he asked "Do scientist have to follow a stepwise procedure to get a reliable and valid knowledge?" The findings indicated that pre-service teachers believed that scientists follow a single scientific method for achieving true knowledge.

Significance of the study

Despite the importance of scientific method domain of NOS, our knowledge base about pre-service science teachers' views about scientific method is limited. More detailed descriptions of pre-service science teachers' views about scientific method are needed in order to design teacher education programs which have a potential to enhance pre-service science teachers' conceptions of scientific method. However it was seen in the literature that pre-service teachers' views of NOS were generally assessed as a whole (instead of separate domains) by using multiple choice surveys which force participants to choose between predetermined views. Also some of the researchers who tried to assess pre-service teachers views of NOS as a whole including all domains such as role of scientist, scientific knowledge, scientific method, scientific laws etc. concluded that pre-service teachers have mixed views (traditional and contemporary) about NOS. So, highly traditional view in one domain may be neutralized as a contemporary view in another domain when the total view is considered. For instance, in their study Palmquist and Finley (1997) assessed pre-service teachers' views on NOS and concluded that participants enter teaching program with mixed views about NOS. However, when pre-service teachers' views on each domain of NOS examined separately, it was seen that majority of participants held a traditional view of scientific method. So the researcher of this study believed that a detailed investigation about scientific method views of pre-service teachers is needed. To this end, this study aims to contribute to the relatively limited literature on pre-service science teachers' conceptions of scientific method.

The research questions were:

(1) What are the pre-service science teachers' conceptions of scientific method?

(2) Are these conceptions are general or subject specific?

Method

Subject

346 pre-service science teachers, 62 male and 284 female, all of whom were in the same university, participated in the study. The number of participants in their 1st, 2nd, 3rd and 4th year was 102, 84, 93 and 67 accordingly. All of the subjects participated in the study voluntarily.

Context of the study

Before explaining the characteristics of the study and interpreting the findings it is useful to describe the context within which this investigation was conducted. In this study the pre-service science teachers who were seeking certification in elementary level science were chosen from a public university. This university accepts students from the top %10 through a national university entrance examination. They were attending 4 year program that includes both science and education courses. In the first year they required to take general chemistry, principle physics, and mathematics courses. Following year courses are the complementary of the previous one (such as organic and analytical chemistry, optics and modern physics) and two education courses (instructional principles and methods and science and technology curriculum). Students take physiology, genetic and biotechnology, geology and environment sciences courses plus more education courses in the third year (educational statistics, laboratory application in science, methods of scientific research, measurement and assessment). The last year courses are mainly related to education (school experience, guidance, classroom management, instructional technology and material development). Also in this year students should take two elective courses among the alternatives (nature of science, constructivist science teaching, misconceptions in science education, project based science teaching, history of science, problem based science teaching, technology in science education etc.). At the time of this investigation, none of the participants had taken the NOS courses.

Data collection and analyses

Data were collected through written responses to survey that includes 3 open ended questions and interviews. The survey questions developed by the researcher were administered in order to examine pre-service science teachers' views about scientific method. Survey questions were administered to all participants individually and it approximately took 30 minutes to complete the questions.

The survey questions were prepared in the native tongue of the participants by the researcher. However to report the results for the article, the researcher translated the questions into English and a specialist in linguistics was asked to retranslate it into original language. At the end of this double translation process, it was seen that the

original form of the survey and the retranslated one were very similar.

The interviews were conducted in accordance with the answers given to the open ended questions. For each grade level 5 participants were selected randomly for interview. The aim of interview was to clarify participants' responses to survey questions and investigate their answers in depth. During the interviews, participants were given their answer sheets in order to remind answers. The researcher requested interviewees to clarify and elaborate their answers. Each interview lasted approximately 15 minutes. Before administering the survey and conducting the interviews, participants were informed about the purpose of the study both orally and in writing. Also they were explained that the data would remain confidential and anonymous; and their participation was not mandatory.

The technique used for analyzing the responses to open ended questions was analytical induction (Bogdan& Biklen,1992; Abell & Smith, 1994). In the first stage of the analysis, in order to find a common pattern participants' responses to the open ended questions and interview data were read over and over. Then by using these patterns emergent categories were generated. When the responses did not fit any categories they werelabelled and reported as "uncategorized". The open ended questions were given in the following table.

Table1. Survey questions

1. What does "scientific method" mean to you? Explain in your own words.
2. Do scientists have to follow a single scientific method to get scientific knowledge? Please explain your reason?
3. Does the way of getting reliable knowledge in physics, chemistry and biology the same or different?

In the following section written quotes or interview excerpts of participants' views are given in order to define and substantiate the categories. Moreover at the end of each questions number of participants in each category with respect to grade level is presented forexplanation.

Results

What is scientific method?

Pre-service science teachers' responses to the first question revealed five categories; "A is A", "making experiment/ observation", "predetermined steps", "method used by scientific community", and "contemporary view".

A is A

Although answers grouped under this category do not contradict with contemporary view of scientific method; they do not provide any new information about scien-

tific method. Rather concept of scientific method is assimilated into general notion of method. Following excerpt is an example for this category;

"Scientific method is a way of solving scientific problems"

Making experiment/observation

In this category, participants thought that it is making experiment/observation that distinguishes scientific method from other methods. Unlike "A is A" view, pre-service teachers have a new schema for scientific method albeit limited to experiment or observation. They conceived that making experiment and/or observation is the only way of getting scientific knowledge. 22% of the participants in this category put a hierarchy between experiment and observation. In the following excerpt one of the participants exemplified this view:

> "Scientific method starts with a careful observation. Observation is the heart of scientific method. To ensure the validity of obtained knowledge, one should first make an unbiased observation, and then according to results of this investigation, a controlled experiment should be conducted"

Their view reflects the point that one should first make an observation and according to results of this observation than a controlled experiment should be made in order to solve a given problem. Moreover some of the participants explained that experiments are needed to be conducted in laboratories with sophisticated equipments (17%).

Predetermined steps

Almost half of the participants' view in this study fitted this category(40%). According to them following the steps (either some or all) of scientific method is necessary for both getting scientific knowledge and increasing the validity and reliability of it. It was seen in pre-service science teachers responses that formulating hypothesis, testing hypothesis, framing laws and theories were the most commonly stated steps

> "Although I cannot remember all, I know that scientific method involves 8 steps. The steps begin with stating the hypothesis and scientists follow these steps in order to get scientific knowledge"

%62 of the participants in this category also stated that the order of these steps cannot be changed; i.e. second step cannot be conducted unless the first one is completed. In the following excerpt this view is evident;

> "Scientific method involves steps that include making observation, suggesting hypothesis, testing hypothesis with controlled experiment, framing laws and if the laws are supported by additional data, raising theories. These steps are used by all scientists universally. The sequence of these steps can not changed"

Method used by scientific community

Responses in this category did not reflect any predetermined steps, but they pointed out scientific community to define scientific method. Most of the statements in this category mentioned that scientists use scientific method to obtain scientific knowledge/ observe nature/investigate given problem. Necessity of using scientific method by scientists to produce scientific knowledge accepted and validated by all scientific community was the other notable view in this category. Moreover some of the participants argued that scientific method facilitate the communication among scientists since it has well accepted by the community.

Contemporary view

The last category reflects participants' view that is compatible with the contemporary view of scientific method. The pre-service teachers in this category realized that traditional scientific method is not the unique way of getting scientific knowledge. They actually defined scientific method by explaining what it is not. It is common in the responses that we cannot describe a rigid scientific method that all scientists should use. Also %8 of the participants indicated that there is no scientific method. One of the participants' responses exemplifies this view as follows:

> "…….I think the important point is to describe the procedure clearly in order to replicate study by others for verification. I believe everyone creates their own way of investigation…."

The following table shows the percentage of students' responses fitted the categories in each grade level.

Table 2. Percentage of participants' responses to the first question

Categories	Grade levels			
	1	2	3	4
A is A	9	8	7	7
Making experiment/observation	12	11	20	18
Predetermined steps	42	45	39	33
Methods used by scientist	9	11	7	6
Contemporary view	21	22	22	33
Uncategorized	7	3	5	3

Existence of a single scientific method

In the second question of the survey, pre-service science teachers were asked whether scientists have to follow a single scientific method to get scientific knowledge or not. The participants who believed the existence of a single scientific method supported their claim by using various arguments. Their arguments can be categorized as

follows:

Science is not compatible with ambiguity in nature

Pre-service science teachers whose answers can be classified under this category thought that existence of more than one scientific method impairs the accuracy of science. They argued that scientific community agrees on the single scientific method with clearly stated boundaries and only this method ensures the validity and reliability of the knowledge obtained from any investigation.

The participants defining scientific method as predetermined steps made use of these steps also in this question and even some of them claimed that any change in the sequence of these steps causes uncertainty. However others stated that although scientists should follow these steps, they are free to decide what kind of activities can be done for each step.

> "……For example after formulating the hypothesis, scientists should test it. In this step a scientist can apply different procedure to test the hypothesis. After testing process she/he can pass the third step… "

Moreover, another notable view under this category was that only when scientists use a universally accepted single scientific method, we can call their investigations as scientific, since just the usage of this method permits the duplication of their studies exactly in the same way by other scientists.

Scientific knowledge is absolute

In this category the participants acknowledged a very traditional view that scientific knowledge is free from the influence of context and individuals. Scientists can get purely objective knowledge merely by using a scientific method which has a certain frame predetermined in advance and accepted by everyone. Otherwise, each distinct method produces different knowledge and it is troublesome to decide which one is scientific. However, when scientist uses a scientific method which is universally accepted, the results are absolutely true without any doubt. For example, a pre-service teacher whose scientific knowledge view is highly traditional explained his view as:

> "Scientific knowledge reflects reality and it should be objective. Scientist reaches scientific knowledge through an ordered and careful study. Only this study called scientific method has unique and universally accepted yields an objective scientific knowledge"

Scientific method is an umbrella

Pre-service science teachers' views reflected that scientists have to follow a single scientific method to get scientific knowledge since it includes all the procedure that scientists use in their investigations. Participants argued that scientific method is an inclusive term that may include various kinds of activities. Although the content

of the activities were not stated explicitly, pre-service teachers claimed that all these activities form scientific method. They expressed the belief that scientific method is a general guideline.

Pre-service science teachers who did not accept the existence of a single scientific method constituted the 56% of all participants. Their views were categorized as "role of context" and "scientific knowledge is tentative"

Role of context

The responses of participants grouped under this category were compatible with the contemporary views of NOS. They stated that the scientific method used to get scientific knowledge may change with respect to subject area and scientists. The participants who claim that scientists may choose the appropriate scientific method in their investigations seem to accept the role of scientists' prior knowledge and creativity in any scientific endeavour.

15% of all participants believed that the scientific methods used in social and natural/applied sciences cannot be same since the nature of problems they deal with is quite different.

Scientific knowledge is tentative

Some of the pre-service teachers extended their conceptions about scientific knowledge to scientific method. Nearly 10% of the participants indicated that scientific method is subject to change just like scientific knowledge:

> "Today's reliable method may change in the future and be classified as ineffective or unreliable. So something that is not durable to time cannot be unique"

Moreover technological development was also associated with the changes in scientific method. Participants explained their reason by claiming that the instruments we used to get scientific knowledge are changed with progression in technology and these instruments in turn alter our scientific method.Table 3 shows the percentage of pre-service teachers' responses to second question according to grade level.

Table 3. Percentage of participants' responses to the second question

	Grade levels			
Views	1	2	3	4
"Yes" with clear reason	45	41	44	30
"No" with clear reason	53	58	56	57
Uncategorized	2	1	0	3

Subject dependence of scientific method

In the last question, participants were asked whether the way of getting reliable knowledge in physics, chemistry and biology are the same or different. It was seen in the table 4 that almost half of the first year participants thought that scientists use different methods in their investigations about different subjects.

Table 4. Percentage of participants' responses to the third question

Views	Grade levels			
	1	2	3	4
Same	42	36	30	29
Different	53	61	63	69

The reasons of the pre-service teachers' answers that were classified as "Yes" to this question were analyzed under 2 categories:

Nature of the produced knowledge

The participants' responses under this category reflect the view that the certainty of these three sciences is different. According to them physics is a science which is more precise than chemistry and biology. The theories and laws produced in physics are powerful since they involve numerical expression which is a sign of accuracy. Unlike physics, biological knowledge cannot be explained by using numbers so they are not as accurate as physical knowledge. The pre-service teachers concluded that if the nature of produced knowledge is different, than the way of getting this knowledge should be also different.

Nature of problem

Participants under this category concentrated on the subject to be investigated. They claimed that the nature of problem in physics, chemistry and biology is different. So, scientists should approach these problems with different methods. For example %7 of the total subject argued that it is suitable to investigate a problem in chemistry in laboratory by experimentation. Nevertheless biology and physics are more compatible with observation in nature. The following is an excerpt from a third year participants;

> "…Although heat and temperature is a common subject in physics and chemistry, a chemist investigate this subject in laboratory by making some experiment, whereas a physicist may use different method"

The participants who claimed the way of getting reliable knowledge in physics, chemistry and biology are the same explained their answers by using two main reasons. The first argument reflects the category "Predetermined steps" came off in the

first question. %66 of the participants who said "No" to third question explained that scientific method involves universally accepted fixed step-by-step process. Other respondents clarified their responses by claiming that scientific knowledge is objective which is a compatible view with the category of "Scientific knowledge is absolute" emerged in the second question.

Discussion and Conclusion

The myth of existence of a single scientific method is considered as an important aspect of NOS (Urhahne, Kremer, & Mayer, 2010; Abd-El-Khalick, Waters,& Le, 2008; Palmquist & Finley, 1997). This study aimed to investigate pre-service science teachers' conceptions of scientific method by using three open ended questions and follow- up interviews. Individual type responses to open ended questions generate themes in greater detail than those obtained from traditional multiple choice instruments (Neuendorf, 2002). So the questionnaires or interviews such as those in this study allow researchers to produce deeper insights on NOS. In the following part of the paper the discussion of results based on three research questions was presented.

The first research question was directed to investigate the conceptualizations of pre-service science teachers held about the meaning of scientific method. The analytical induction used in this study revealed that the participants' conceptions about scientific method were classified under 5 categories. Three of the emerged categories namely making experiment/observation, predetermined steps and contemporary view were similar to those found in previous studies (Urhahne, Kremer, and Mayer 2010; Abd-El-Khalick, Waters,&Le, 2008). In this study 40% of the all participants defined scientific method as predetermined steps, this corroborates the findings of Abd-El-Khalick (2004). The other notable viewwas that scientific method is "Making experiment/observation". This finding is in agreement with the previous research in that science education is based on logical empiricist view of science. For instance Turgut (2009) concluded that "The core of prospective science teachers' conceptualizations of scientific method was experimentalism". Inconsistent with earlier studies that reported very low percentage for participants having a contemporary view (e.g. Abd-El-Khalick,2004); it was found that 25% of the pre-service teachers held contemporary view about scientific method in this study. In addition to these, "A is A" and "method used by scientific community" categories were specific to this study. Although the former one does not give any profound information, the subsequent category enhanced our knowledge base about pre-service science teachers' conceptions about scientific method.

It might be the case that the previously discussed reasons in the literature were responsible for participants' poor understanding about scientific method herein. Palmquist and Finley (1997) argued that cookbook type laboratory activities direct pre-service teachers to describe science as a strict investigation which generate reliable

and valid knowledge. Moreover their uninformed conceptions may be consolidated by a universal, stepwise scientific method in school science textbooks (Craven et al., 2002; Haidar,1997). It is somewhat surprising to find that some of the participants referred to research articles when elaborating their view. These articles generally involve a literature, method (participants, data collection instruments, data collection process) data analysis, result and discussion parts which leads pre-service teachers to portray science as procedural in nature. So it is possible to hypothesize that the presentation of research articles published in journals mightsolidify pre-service teachers' naïve conceptions of scientific method.

The second research question was designed to investigate pre-service science teachers' conceptions about the existence of a single scientific method. The analyses of the participants' responses revealed that 40% of them believed that there is a single scientific method. This response pattern showed the common myth of there is a prescribed sequence of research steps to get scientific knowledge. The participants explicated their concept of single scientific method by using 3 arguments; science is not compatible with ambiguity in nature, scientific knowledge is absolute and scientific method is an umbrella. The reason of this view might be due to participants' laboratory work. They had worked in laboratories as a junior scientist and did not apply inquiry in the laboratories (Palmquist & Finley, 1997).

The final research question focused on the subject dependence of scientific method. It is interesting to note that 62% of the total participants claimed that the way of getting reliable knowledge in physics, chemistry and biology are different. It is remarkable that although 40% of the participants believed the existence of a single scientific method, this percentage decreased (34%) when subject is considered. This may shows us that their concept of scientific method is not well integrated. To facilitate pre-service teachers' conceptions of scientific method, they can be introduced some anecdotes relevant to scientist' knowledge construction process in basic science courses. By this way, they will be given a chance to think about their myth of scientific method and compare it with contemporary view.

One recommendation for further research would be to address pre-service science teachers' conceptions of scientific method explicitly during their science and method courses. In our case, the participants only had a chance to discuss their NOS view in their last year elective course. Nevertheless, their scientific method concept can be facilitated by instructions about NOS including explicit and reflective discussions that are spread out their 4 year education.

Özet

Giriş

Bilimin doğası kavramı, bilimin ne olduğu, nasıl işlediği, toplumun bu işleyişteki etkisi ve bilim komitesinin nasıl çalıştığı ile ilgilenen geniş bir kavramdır (McComas, Clough, & Almazroa, 1998). Lederman'a (2007) göre bilimin doğası; bilimin epistemolojisini, bir bilme yöntemi olarak bilimi veya bilimsel bilgideki ya da onun gelişimindeki değer ve

inançları içerir. Tarihçiler, felsefeciler ve fen eğitimcileri her ne kadar bilimin doğasının tanımı konusunda ortak bir görüşe varamamış olsalar da (Alters, 1997) ilköğretim seviyesinde bilimin doğasının hangi özelliklerinden bahsedileceği konusunda bir anlaşma sağlanmıştır (Abd- El- Khalick, 2004).

Literatürdeki araştırmalar bilimin doğasının bilim okuryazarlığının önemli bir parçası olduğunu vurgulamaktadır. Bunun yanı sıra fen eğitimi alanında yapılan çalışmalar öğretmenlerin ve öğrencilerin bu konuyu anlamada yetersiz olduklarını göstermektedir (Walls, 2012; Akerson & Donnelly, 2010; Meyling, 1997; Ryan & Aikenhead, 1992). McComas (1998) bu konuyu anlama yetersizliğini bilimin mitleri olarak adlandırmıştır. Literatürde öğretmen adaylarının bilimin doğası hakkındaki görüşlerini değerlendiren çalışmalara sıkça rastlanmaktadır (Buaraphan, 2011; Craven, Hand & Prain 2002; Murcia & Schibeci, 1999). Fakat özel olarak öğretmen adaylarının bilimsel yöntem hakkındaki görüşlerini araştıran çalışmaların sayısı oldukça azdır. Literatür incelendiğinde öğretmen adaylarının bilimsel yöntemi bilim insanlarının bilimsel bilgiyi elde etmek için kullandıkları düzenli adımlar olarak algıladıkları ve başarılı bir bilim insanı olabilmek için bu adımların takip edilmesi gerektiğini düşündükleri görülmektedir (Haidar, 1997; Turgut, 2009; Murcia & Schibeci, 1999; Palmquist & Finley, 1997). Buaraphan (2011) bilimin mitleri anketini kullanarak fizik öğretmenliği adaylarının bilimin doğasının dört boyutu ile ilgili görüşlerini incelemiştir. Bu çalışmanın sonuçlarına göre katılımcıların 2/3' ü bilimsel yöntemi kesin, değişmeyen basamaklar dizisi olarak açıklamışlardır. Murcia ve Schibeci de (1999) 73 öğretmen adayı ile yaptıkları çalışmada benzer sonuçlara ulaşmışlardır. Turgut (2009) ise 70 öğretmen adayı ile yaptığı çalışmada katılımcılara 4 açık uçlu sorudan oluşan bir anket uygulamış ve 10 kişi ile de görüşme yapmıştır. Araştırmanın sonucuna göre öğretmen adaylarının çoğu realist bir bakış açısı sergileyerek "doğru" bilimsel bilgi elde etmek için izlenecek tek bir bilimsel yöntem olduğunu savunmuşlardır.

Bu bağlamda bu çalışmanın öğretmen adaylarının bilimsel yöntem konusundaki görüşleri ile ilgili kısıtlı literatüre katkı sağlayacağı düşünülmüştür. Bu araştırmada aşağıdaki sorulara cevap aranmaktadır:

(1) Fen bilgisi öğretmen adaylarının bilimsel yöntem hakkındaki görüşleri nelerdir?

(2) Bu görüşler genel midir yoksa çalışılan konuya bağlı mıdır?

Yöntem

Örneklem

Bu çalışmaya bir üniversitenin farklı sınıflarında öğrenim gören 284'ü kız, 62'si erkek 346 fen bilgisi öğretmen adayı katılmıştır. Katılımcıların 102'si 1.sınıf, 84'ü 2. sınıf, 93'ü 3. sınıf ve 67'si 4. sınıf öğrencisidir. Çalışmaya öğretmen adaylarının tamamı gönüllü olarak katılmıştır.

Veri Toplama ve Veri Analizi

Verilerin toplanması aşamasında öğretmen adaylarına araştırmacı tarafından geliştirilen 3 adet açık uçlu sorudan oluşan bir anket verilmiştir. Amacı öğretmen adaylarının bilimsel yöntem hakkındaki görüşlerini değerlendirmek olan bu sorular bütün katılımcılara bireysel olarak uygulanmıştır. Katılımcıların anketi tamamlamaları yaklaşık 30 dakika sürmüştür. Öğretmen adaylarının açık uçlu sorulara verdikleri cavaplara göre her sınıftan 5'er kişi ile görüşme yapılmıştır. Görüşmeler ses kayıt cihazı ile kaydedilmiştir. Görüşmelerin amacı katılımcıların anket sorularına verdikleri yanıtları derinleştirmelerini sağlamaktır. Nitel veriler analitik tümevarım yöntemi ile analiz edilmiştir (Bogdan & Biklen, 1992; Abell & Smith, 1994).

Bulgular

Bilimsel yöntem nedir?

Katılımcıların bu soruya verdikleri yanıtlar "A, A'dır", "deney/gözlem yapmak", "önceden belirlenmiş basamaklar", "bilim komitesi tarafından kullanılan yöntemler" ve "çağdaş görüş" olmak üzere 5 kategoride incelenebilir.

A, A'dır

Bu kategorideki görüşler her ne kadar çağdaş görüş ile çelişmese de öğretmen adaylarının bilimsel yöntem hakkında ne düşündükleri ile ilgili yeni bir bilgi vermezler. Bu gruptaki katılımcılar bilimsel yöntem ile ilgili görüşlerini, genel olarak yöntem kavramından oluştururlar.

Deney/gözlem yapmak

Bu kategoride yer alan öğretmen adayları bilimsel yöntemi diğer yöntemlerden ayıran özelliğin deney ve gözlem yapmak olduğunu söylemişlerdir. Katılımcılar bilimsel bilgi elde etmenin tek yolunun deney ya da gözlem yapmak olduğunu savunmuşlardır. Ayrıca bir problemi çözmenin yolu önce o problem ile ilgili gözlem yapmak daha sonra bu gözlemlere dayanarak kontrollü deney tasarlamak olarak belirtilmiştir.

Önceden belirlenmiş basamaklar

Katılımcıların verdikleri cevapların neredeyse % 50'si bu kategoride yer almaktadır. Öğretmen adayları önceden belirlenmiş basamakları takip etmenin hem bilimsel bilgi elde etmede hem de elde edilen bilginin geçerlik ve güvenirliğini artırmada gerekli olduğunu savunmuşlardır. Hipotez kurma, hipotezleri test etme, kanun ve teori oluşturma en çok bahsedilen basamaklar olmuştur. Ayrıca katılımcıların % 62'si bilimsel yöntemin basamaklarının kesinlikle değiştirilemeyeceğini savunmuşlardır.

Bilim komitesi tarafından kullanılan yöntemler

Bu kategoride olan görüşler hiçbir basamaktan bahsetmezken, bilimsel yöntemi açıklamak için bilim komitesinden sıklıkla bahsetmişlerdir. Bilimsel bir bilgi elde etmek için

bilimsel yöntemi kullanmak bilim komitesi tarafından kabul edilen ve geçerli görülen bir yoldur. Bazı öğretmen adayları bilimsel yöntemi kullanmanın bilim insanları arasında iletişimi kolaylaştırdığını savunmaktadır.

Çağdaş görüş

Bu kategorideki öğretmen adayları bilimsel bilgi elde etmenin tek yolunun bilimsel yöntemi kullanmak olmadığının farkındadırlar. Burada açıklamalar genellikle bilimsel yöntemin ne olmadığı üzerine yoğunlaşmıştır. Bilim insanlarının hepsinin kesinlikle kullanması gereken katı bir yöntemden bahsedilemeyeceği bu kategorideki en tipik görüştür.

Tek bir bilimsel yöntemin varlığı

Anketin 2. sorusu katılımcıların bilim insanlarının bilimsel bilgi elde etmek için tek bir bilimsel yöntem kullanmak zorunda olup olmadıkları hakkındaki görüşlerini almak için hazırlanmıştır. Tek bir bilimsel yöntemin varlığına inanan katılımcılar cevaplarını farklı şekillerde gerekçelendirmişlerdir. Bunlar:

Bilimin doğasında belirsizlik yoktur

Bu kategorideki cevaplar birden fazla bilimsel yöntemin varlığının bilimin kesinliği ile bağdaşmayacağını savunmaktadır. Katılımcılara göre bilimsel komite sınırları belirlenmiş bir bilimsel yöntem üzerinde anlaşmıştır ve sadece bu yöntem elde edilen bilginin geçerliğini ve güvenirliğini garanti eder.

Bilimsel bilgi kesindir

Bu kategorideki görüşler bilimsel bilgi ile ilgili geleneksel bir bakış açısına sahiptir. Bilim insanları bilimsel yöntemin basamaklarını izleyerek tamamen objektif bir bilgiye sahip olabilirler. Katılımcılar birden fazla bilimsel yöntemin olması durumunda bu yöntemlerden yararlanılarak yapılan araştırmaların sonucunda elde edilen bilgilerin hangilerinin "doğru" olduğuna karar veremeyeceğimizi iddia etmişlerdir.

Bilimsel yöntem bir şemsiyedir

Öğretmen adayları bilimsel bilgi elde etmenin tek yolunun bilimsel yöntemi kullanmak olduğunu savunurlar çünkü bilimsel yöntem bilim insanlarının kullandığı bütün prosedürleri içerir. Katılımcılar bilimsel yöntemin farklı eylemleri kapsayıcı bir terim olduğunu iddia ederler.

Tek bir bilimsel yöntemin varlığını kabul etmeyen katılımcılar örneklemin % 56'sını oluştururlar. Bu katılımcıların görüşleri "bağlamın rolü" ve "bilimsel bilginin değişebilirliği" kategorilerinde incelenmiştir.

Bağlamın rolü

Bu kategorideki cevaplar bilimsel bilgi elde etmek için kullanılan yöntemin bilim in-

sanına ve çalıştığı alana bağlı olarak değişebileceği görüşünü yansıtır. Katılımcıların % 15'i sosyal alanlarda ve fen bilimlerinde çalışılan problemin doğası farklı olduğundan bu problemleri araştırmak için seçilen bilimsel yötemin de farklı olacağını savunmuşlardır.

Bilimsel bilginin değişebilirliği

Bazı öğretmen adayları bilimsel bilgi hakkındaki görüşlerini bilimsel yöntemi de kapsayacak şekilde genişletmişlerdir. Katılımcıların % 10'u bilimsel bilgi gibi bilimsel yöntemin de değişebileceğini savunmuşlardır. Bu değişimi de teknolojideki gelişmelerin kullandığımız aletleri değiştireceği, bu değişimin de sonuç olarak yöntem değişikliklerine sebep olacağı argümanı ile desteklemektedirler.

Bilimsel yöntemin alana bağlılığı

Son olarak katılımcılara fizik, biyoloji ve kimya alanında bilimsel bilgi elde etmenin yönteminin aynı olup olmadığı sorulmuştur. Bu soruya "evet" yanıtını veren öğretmen adaylarının açıklamaları iki kategoride incelenebilir:

Üretilen bilginin doğası

Bu kategorideki öğretmen adayları bu bilim dallarının kesinliğinin aynı olmadığını savunurlar. Onlara göre fizik; kimya ve biyoloji bilim dallarından daha kesin bilgiler üretir. Fizikte ortaya atılan kanunlar sayısal veriler içerdiğinden daha güçlü ve daha kesindir. Bu görüşten yola çıkarak katılımcılar kesinlikleri farklı olan bilgileri elde etme yollarının da farklı olması gerektiği sonucunu çıkarırlar.

Problemin doğası

Katılımcılar araştırılacak konu üzerinde yoğunlaşırlar ve fizik, kimya ve biyolojide araştırılacak problemlerin doğasının farklı olduğunu öne sürerler. Bu durumda bilim insanları da bu problemlere farklı yöntemlerle yaklaşmalıdır. Örneğin katılımcıların % 7'si kimya alanındaki herhangi bir problemi araştırmanın en uygun yolunun laboratuvarda deney yapmak olduğunu, fakat fizik ve biyoloji alanındaki problemlerle ilgilenmenin yolunun ise doğada gözlem yapmak olduğunu savunmuşlardır.

Fizik, kimya ve biyolojide bilimsel bilgi elde etmek için aynı yöntemin kullanılabileceğini savunan adaylar iki farklı argümandan birini kullanmışlardır. Birinci argüman birinci soruda "önceden belirlenmiş basamaklar kategorisi" ile açıklanan görüşe paraleldir. Katılımcıların % 66'sı bilimsel yöntemi önceden belirlenmiş basamaklar olarak algıladıkları için çalışılan alanın yöntemi değiştirmeyeceğini savunurlar. Diğer argüman ise bilimsel bilginin kesin olduğu ve bunun çalışılan alandan bağımsız olduğu ve dolayısıyla bu bilgiyi elde etmenin de tek bir yolu olduğudur. Bu görüş "bilimsel bilgi kesindir" kategorisindeki görüşler ile uyumludur.

Sonuç/Tartışma

Tek bir bilimsel yöntemin var olduğu miti bilimin doğası ile ilgili önemli yanlış görüşlerden biridir (Urhahne, Kremer, & Mayer, 2010; Abd-El-Khalick, Waters, & Le, 2008; Palmquist & Finley 1997). Bu çalışma öğretmen adaylarının bilimsel yöntem hakkındaki görüşlerini ortaya çıkartmak için yapılmıştır. Birinci sorunun analizi 5 farklı kategoride incelenmiştir. Bunlardan 3'ü (deney/gözlem yapmak, önceden belirlenmiş basamaklar ve çağdaş görüş) bundan önce yapılan çalışmalar ile ortaktır (Urhahne, Kremer, & Mayer, 2010; Abd-El-Khalick, Waters, & Le, 2008). Diğer iki kategori ise ilk kez bu çalışmada bahsedilen kategorilerdir. "A, A'dır" kategorisi her ne kadar bize yeni bir bilgi vermese de "bilim komitesi tarafından kullanılan yöntemler" kategorisi bu konudaki fikirlerimizi derinleştirmektedir. Palmquist ve Finley (1997) yemek kitabı şeklinde hazırlanan laboratuvar etkinliklerinin öğretmen adaylarının bilimsel yöntem hakkındaki yanlış görüşlerinin sebebi olduğunu ileri sürmüşlerdir. Ayrıca katılımcıların görüşlerindeki bu yanlışlık ders kitaplarındaki, bilimsel yöntemin evrensel gösterimi ve basamaklar şeklindeki gösterimi ile somutlaşmaktadır (Craven ve diğerleri, 2002; Haidar, 1997). Araştırmanın ikinci problemi öğretmen adaylarının tek bir bilimsel yöntemin varlığı ile ilgili görüşlerini almak için hazırlanmıştır. Katılımcıların % 40'ı tek bir bilimsel yöntemin var olduğunu düşünmektedir. Bu görüşün sebebi katılımcıların laboratuvar çalışmalarına bir bilim insanı olarak değil de öğrenci olarak katılmaları olabilir (Palmquist & Finley, 1997). Son araştırma sorusu bilimsel yöntemin araştırma alanına bağlı olup olmadığı ile ilgilidir. Katılımcıların % 62'si fizik, kimya ve biyolojide kullanılan bilimsel yöntemin aynı olmadığını savunmuştur. Katılımcıların % 40'ı tek bir bilimsel yöntemin varlığından bahsederken, araştırma alanı söz konusu olduğunda bu oranın % 34'e düşmüş olduğu gözlenmektedir. Bu da bize öğretmen adaylarının konu ile ilgili görüşlerinin tutarlı olmadığını göstermektedir. Bilim insanlarının bilimsel bilgi üretme süreçleri ile ilgili hikâyeleri, fen derslerinde öğretmen adaylarıyla paylaşmalarının öğretmen adaylarının bilimsel yöntem hakkındaki görüşlerinin daha sağlıklı olmasını sağlayacağına inanılmaktadır.

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