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Pre-service Science Teachers' Nature of Science Understandings' Influence on Their Socioscientific Argumentation Quality*

Fen Bilgisi Öğretmen Adaylarının Bilimin Doğası Anlayışlarının Sosyobilimsel Argümantasyon Kaliteleri Üzerindeki Etkisi

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Abstract. The purpose of this study is to investigate pre-service science teachers' (PSTs') nature of science (NOS) understandings' influence on their socioscientific argumentation quality. This study was conducted with 12 participants whom were chosen with maximum variation sampling method among 27 PSTs. The class of the participants was chosen by basic random sampling method. This study, which contains both qualitative and quantitative processes, is an explanatory mixed method in which quantitative data are used in more detail than qualitative data. For this study, which lasted 11 weeks in total, three groups with four participants in each were formed. Presentations, whole-class discussions and small group discussions were made for participants to learn fundamental knowledge about the NOS and socioscientific argumentation; and to have them basic argumentation formation skills. Qualitative and quantitative data analyses indicate that understanding (low, medium, high) of the NOS impacts socioscientific argumentation quality. Our results also indicate that superior understanding of the NOS also predicts socioscientific argumentation quality.

Keywords: Socioscientific argumentation, nature of science, argumentation quality, pre-service science teacher

Öz. Bu araştırmanın amacı; fen bilgisi öğretmen adaylarının bilimin doğası anlayışlarının sosyobilimsel argümantasyon kaliteleri üzerindeki etkisini incelemektir. Araştırma, Türkiye'deki bir devlet üniversitesinde öğrenim gören 27, üçüncü sınıf fen bilgisi öğretmen adayının içinden amaçlı örnekleme yöntemlerinden maksimum çeşitlilik örnekleme yöntemi kullanılarak seçilen 12 katılımcıyla gerçekleştirilmiştir. Hem nicel hem de nitel süreçleri içeren bu çalışma, nicel verilerin nitel verilere göre daha ayrıntılı olarak kullanıldığı açıklayıcı karma yöntem aracılığıyla gerçekleştirilmiştir. Araştırmaya dâhil olan tüm katılımcıların bilimin doğası ve sosyobilimsel argümantasyon konusunda temel bilgilere ve temel argüman oluşturma becerilerine sahip olabilmeleri için bu konular hakkında sunumlar, sınıf tartışmaları ve küçük grup tartışmaları yapılmıştır. Nitel ve nicel veri analizlerinin sonunda; bilimin doğası anlayışlarının sosyobilimsel argümantasyon kalitesini anlamlı olarak etkilediği sonucuna ulaşılmıştır. Buna göre, bilimin doğası anlayışları geliştikçe sosyobilimsel argümantasyon kalitesinin de yükseldiği ortaya çıkmıştır..

Anahtar Sözcükler: Sosyobilimsel argümantasyon, bilimin doğası, argümantasyon kalitesi, fen bilgisi öğretmen adayı

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INTRODUCTION

As a renewed approach, the NOS, along with socioscientific issues and argumentation, became one of the components of scientific literacy in the field of science education (e.g. ACARA, 2014; NRC, 2013). Contemporary science education not only proposes students to be taught scientific concepts, but it also demands them to participate in discussions regarding social and technological repercussions of scientific problems and to be raised as qualified decision makers (Kuhn, 2010; Sadler & Zeidler, 2005). Nowadays, developments that have been taking place in science and technology (e.g. biotechnology implementations, construction of nuclear power plants, GMO production, etc.) have a characteristic of bringing about a process that generates contradictions on the ethical, cultural and moral/religious values of individuals living in a society; as well as affecting them with the basic scientific knowledge that they have revealed. Therefore, making evaluations on the subject of socioscientific issues, which contain science-technology-society relation, is not a one-way process like evaluating validity and reliability of arguments related to any other subjects or drawing conclusions from observations. Accordingly, involving students to the process of argumentation will help them to be raised scientific literacy members of the society (Sampson & Clark, 2011). Researchers, who are in consensus that the goal of science education is to raise scientifically literate students, state that teachers have crucial roles to achieve this goal (e.g. Kuhn, 2010; Lederman, 2007). Zembal-Saul (2009) has suggested that PSTs' involvement in the context of socioscientific issues, argumentation and NOS processes will increase the possibility that they will use these processes in their classes; in addition to this, their pedagogic skills will improve. Based upon stated rationales; this study aims to investigate PSTs' NOS understandings' impact on their socioscientific argumentation quality.

The Influence of NOS on Socioscientific Argumentation

Involvement of students in scientific and socioscientific activities, improvement of their epistemic and cognitive skills and the inclusion of argumentation to scientific education in order to understand students' ways of reasoning became a special field of interest for contemporary science education curriculums (AAAS, 2001; NRC, 2013). Recently, numerous studies have been conducted to investigate the effectiveness of socioscientific argumentation (Dawson & Venville, 2010) and the NOS (Abd-El-Khalick & Lederman, 2000) in students reasoning. In recent years, there has been an increasing trend in the number of studies that have been conducted to investigate individuals' way of handling the issue of different aspects of the NOS in the process of socioscientific argumentation (e.g. Khishfe, 2012a, 2014; Walker & Ziedler, 2007). However, when the findings of these studies have been compared, it has been understood that they are not consistent. While some researchers (e.g. Albe, 2008; Zeidler, Walker, Ackett, & Simmons, 2002) were stated that there was a clear relationship between socioscientific argumentation quality or skill and the NOS understanding, other researchers (e.g. Bell & Lederman, 2003; Walker & Zeidler, 2007) claimed that there was no significant relationship between the two. For example, in a study conducted with 82 participants, Zeidler et al. (2002) aimed to investigate relationship between NOS concepts of students and their decisions about socio-scientific issues. Researchers included in to study 41 pairs of students representing of contrasting ethical viewpoints and identified that NOS understandings of students influence their decisions about context of socioscientific issue. In addition, Albe (2008), in her phenomenological study with 12 high school students, examined their socioscientific arguments that consisted about potential impact on human life of mobile phones. She determined that epistemological awareness related students' context of socioscientific issue influences their socioscientific arguments elaborating degrees. On the other hand, in a study conducted with the participation of 21 lecturers by Bell and Lederman (2003) was investigated that effect of NOS understandings in socioscientific decision-making. Results showed that there is no significant role of NOS understandings in socioscientific decision-making process. Finally, in a study conducted with 36 high school students, Walker and Zeidler (2007) intended to promote socioscientific argumentation through web-based teaching and to determine the impact on socioscientific argumentation quality of NOS understandings. Researchers, as a result of qualitative analysis, identified that there is no impact on socioscientific argumentation

quality of NOS understandings. In the context of socioscientific reasoning Sadler (2004) stated that NOS conceptualizations could have a mediate effect and the situation should be considered in science education. Bell and Lederman (2003) claimed that the NOS issue has no affect in the process of socioscientific decision making; instead of that, factors like personal values, cultural/ethical and social relationships should be considered. Argumentation skills contain all the reasoning related to advantages-disadvantages, pros-cons; reasons and results of any issue in consideration of alternative viewpoints (Mason & Scirica, 2006). A number of researchers claim that consideration of different viewpoints depended upon the level of epistemological understanding (e.g. Mason & Scirica, 2006; Schommer-Aikins & Hutter, 2002). In this context, Schommer-Aikins and Hutter (2002) stated that individuals with high epistemological understanding have better skills in context of socioscientific decision making. Accordingly, epistemological believes have effects on students' active participation to the learning environment, overcoming challenging tasks, understanding written materials and dealing with controversial issues. Likewise, Wu and Tsai (2011) suggest that individuals with high epistemological understandings have high informal reasoning quality. In the literature it is clear that findings, collected from studies which were made in order to investigate the impact of the NOS understanding on the quality of socioscientific argumentation, are very limited and so far researches has been mostly done with high school students (e.g. Albe, 2008; Wu & Tsai, 2011). The lack of a study made with teachers or pre-service teachers has been remarked. This gap in the literature and there being no unison consensus on the findings of previous researches constitute the rational of this study.

METHOD

This study, which contains both qualitative and quantitative processes, is an explanatory mixed method in which quantitative data are used in more detail than qualitative data (Cresswell, 2008; Sullivan, 2009). In this research design; in the first phase, quantitative data are collected; then in the second phase, qualitative data are collected, in order to elaborate and explain the quantitative data (Cresswell, 2008). As the first phase of this study, quantitative data were collected from participants by NSAAQ (The Nature of science as argumentation questionnaire) test; and then as the second phase, qualitative data were collected by the process of socioscientific argumentation.

Participants

Twenty-seven PSTs (Male = 4 and Female = 23) who were studying in a science-teaching faculty of a public university participated in this study. The class of the participants was chosen by basic random sampling method (Fraenkel &Wallen, 2006).

Determination of sub-samplings

Three groups (*low-middle-high*), which were homogeneous within group and heterogeneous intergroup, each consisting four members have been formed according to their NSAAQ test results. Groups were chosen with maximum variety method of the sampling methods (Patton, 1990). Information regarding low, middle and high group participants is given in Table 1.

Table 1. *Information regarding low, middle and high group participants*

Group Members		Gender	NSAAQ Test Score
High Group	A_H	F	94.0
	B_H	F	92.0
	C_H	F	92.0
	D_H	M	92.0
Middle Group	A_M	F	85.0
	B_M	F	85.0
	C_M	F	85.0

	D_M	F	85.0
Low Group	A_L	F	74.0
	B_L	F	73.0
	C_L	M	72.0
	D_L	M	70.0

The process of group formation was;

1. NSAAQ test was taken by 27 participants.
2. Point average and standard deviation of test scores were determined and formulas stated below were used (Fraenkel & Wallen, 2006).

$$\text{Arithmetic Mean} + \frac{\text{Standard Deviation}}{2} < \textbf{High Achievers}$$

$$\text{Arithmetic Mean} - \frac{\text{Standard Deviation}}{2} > \textbf{Low Achievers}$$

$$\textit{High Achievers} > \textbf{Middle Achievers} > \textit{Low Achievers}$$

Groups were formed from participants who were not in low, middle and high groups in consideration of their NSAAQ test scores. Thus, all the participants were included in to the socioscientific argumentation process in a group. Members of low, middle and high groups were not aware of the fact that only the data of their groups would be used. So that collected data were not interfered and also active participation of the members of those groups was provided.

Data Collection Tools

Two different data collection tools were used for this study. These tools were introduced in detail below.

The Nature of science as argumentation questionnaire (NSAAQ)

The test, which was developed by Sampson and Clark (2006) and was adapted to Turkish by Cetin, Erduran and Kaya (2010), was conducted to determine understandings of NOS both at the beginning and at the end of the implementation on all of the participants (Figure 1). While developing this test Sampson and Clark (2006) asserted that traditional tests developed for defining individuals' beliefs on the epistemology of science are either field-specific (e.g. VOSTS), or field-general (e.g. VNOS); or they are designed just for the evaluation of attitude and beliefs (VASS). Because of this, researchers needed to develop a quantitative scale in order to specifically evaluate the role of argumentation in the process of the development of scientific knowledge. As it was stated by the researchers, because the traditional tests which were developed for defining the nature of science and epistemological beliefs focus mainly outside the scope of nature of science; NSAAQ test, which is more appropriate for the nature of argumentation, was used for this study. This test was designed to determine an individual's; *nature of scientific knowledge, methods that can be used for producing scientific knowledge, circumstances in which scientific knowledge can be evaluated as valid and reliable and epistemological interpretations related to social and cultural nature of scientific knowledge.* In order to identify reliability co-efficient NSAAQ test was conducted on 254 third grade PSTs in five different universities and cronbach's alpha reliability co-efficient of the test was calculated to be 0,79. This value proves the test to have sufficient reliability (Fraenkel & Wallen, 2006).

The Nature of Science as Argumentation Questionnaire (NSAAQ)

Read the following pairs of statements and then circle the number on the continuum that best describes your position on the issue described. The numbers on the continuum mean:

1 = I completely agree with viewpoint A and I completely disagree with viewpoint B.
2 = I agree with both viewpoints, but I agree with viewpoint A more than I agree with viewpoint B.
3 = I agree with both viewpoints equally.
4 = I agree with both viewpoints, but I agree with viewpoint B more than I agree with viewpoint A.
5 = I completely agree with viewpoint B and I completely disagree with viewpoint A.

	Viewpoint A	A	A >B	A=B	B>A	B	Viewpoint B
1	Scientific knowledge describes what reality is really like and how it actually works.	1	2	3	4	5	Scientific knowledge represents only one possible explanation or description of reality.
2	Scientific knowledge should be considered tentative.	1	2	3	4	5	Scientific knowledge should be considered certain.
3	Scientific knowledge is subjective.	1	2	3	4	5	Scientific knowledge is objective.
4	Scientific knowledge does not change over time once it has been discovered.	1	2	3	4	5	Scientific knowledge usually changes over time as the result of new research and perspectives.

FIGURE 1.*The Nature of science as argumentation questionnaire (NSAAQ)*

Weekly activities

The activity booklets, which were presented to the participants, contain three NOS scenarios and nine socioscientific argumentation scenarios. Socioscientific issues that were used in this study involve factors that encourage participants to easily apply scientific ideas in the argumentation process, while considering informal matters like cultural, ethical and social concerns as it was tested in former studies (e.g. Khishfe, 2012a; Zeidler et al., 2002). These scenarios were prepared by experts in consideration of current issues, in order to make the individuals adopt the stories as if they were real. Certain fictional elements and scientific content in relation with the context have been used in the scenarios. For the approval of the scenarios, in terms of issue context, argumentation, NOS and language.

Table 2. *Socioscientific argumentation scenarios*

Scenario Name	Description
Electric Car Production	This scenario, which was written by Salvato and Testa (2012), has a contradictory plot about the energy resources of electric cars and gasoline-powered cars and their effects on nature. This scenario was adapted to Turkish for this study.
Cell phones Are Threatening Human Life	This scenario discusses harms and benefits of cell phones, which are the mostly used technological gadgets of our time, all together. This scenario, which was written by Salvato and Testa (2012), was used as an adaptation to Turkish.
Golden Rice	This scenario contains a plot in which two groups of scientists defend contradictory knowledge about 'Golden Rice' which is a genetically mutated product developed against vitamin A deficiency. This scenario, which was written by Khishfe (2012b), was adapted to Turkish.
Bio fuel Production	This scenario contains the advantages and disadvantages of bio fuel, which is thought to be one of the alternative power resources, in a single text. It was written by Salvato and Testa (2012) and adapted to Turkish for this study.
Scientists Are Discussing	With this scenario, which represents two opposite views on nuclear power plants- one of the most discussed energy resources of our time-, it was aimed participants to present their argumentations as if they were in a real symposium.

First four of the twelve scenarios presented in the booklet were socioscientific argumentation scenarios. With these scenarios all participants were involved in both small group

and whole class debates to make them get basic argumentation skills. The following three scenarios were NOS scenarios. With these scenarios, it was aimed to improve their understanding of nature and ways of science. The last five scenarios were socioscientific scenarios that had been prepared for data collection. It was aimed to compare socioscientific argumentation qualities of low-middle-high groups. Detailed explanation about these scenarios used, within the data collection process, was given in Table 2.

Procedure

Implementation-data collection process of this study, in which 27 third grade PSTs participated, was lasted for 11 weeks (*two hours for each week*). Firstly, participants were tested with NSAAQ test and in consideration of the results, groups of four were formed. Presentations, whole-class discussions and small group discussions were made for participants to learn fundamental knowledge about the NOS and socioscientific argumentation; and to have them basic argumentation formation skills. Through the end of the process argumentations were demonstrated in accordance with the scenarios above; and they were digitalized with the help of recorders. Only the data of low-middle-high groups were put into written form and prepared for qualitative and quantitative analysis. Procedures made in this process were stated in detail in Figure 2.

Data Analysis

The data collected with this research were analyzed with qualitative and quantitative analysis methods. Procedures followed in both analysis processes were described in detail below.

Qualitative analysis process

In order to determine the socioscientific argumentation qualities of low-middle-high groups; a methodological device developed by Erduran, Simon and Osborne (2004) in accordance with Toulmin Argumentation Model (1958) was used (Table 3).

Table 3. *Argumentation assesing tool*

Argumentation Level	Content
Level I	Argumentation consists of arguments that are a simple claim versus a counter-claim or a claim versus a claim.
Level II	Argumentation has arguments consisting of a claim versus a claim with either data, warrants, or backings but do not contain any rebuttals.
Level III	Argumentation has arguments with a series of claims or counter-claims with either data, warrants, or backings with the occasional weak
Level IV	Argumentation shows arguments with a claim with a clearly identifiable rebuttal. Such an argument may have several claims and counter-claims.
Level V	Argumentation displays an extended argument with more than one rebuttal.

To analyze the argumentation qualities of the groups; *"Electric Car Production", "Cell phones Are Threatening Human Life", "Golden Rice"* scenarios were chosen among the last five scenarios. Analyses were made upon arguments constituted in accordance with these scenarios. The reasons for the selection of these scenarios can be listed as;

- ✓ Because, group discussions lasted longer, data can be seen more clearly,
- ✓ Activity of participants during the process,
- ✓ Participants being more eager during the process (e.g. Erduran et al., 2004).

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PHASES	WEEKS	ACTIVITIES	SCENARIO	SCENARIO CONTENT
I	Week 1	Process introduction and informing participants about the objectives	———	———
II	Week 2	Implementation of NSAAQ Test	———	———
III	Week 3	Forming groups according to NSAAQ Test results Presentation of all aspects of the argumentation	———	———
	Week 4	A short evaluation of the previous week Presentation of all aspects of the argumentation	Scenario 1 (whole/class discussion)	Fossil fuels and nuclear power plants and their environmental impacts
	Week 5	A short evaluation of the previous week Presentation of all aspects of the argumentation	Scenario 2 (whole/class discussion)	The development of biotechnology and cloning applications in the scientific world
	Week 6	A short evaluation of the previous week	Scenario 3 (small group – whole/class discussion)	Advantages and disadvantages of hydroelectric power plants
			Scenario 4 (small group – whole/class discussion)	Environmental impacts of biotechnology and genetic engineering applications
IV	Week 7	A short evaluation of the previous week Presentation about NOS	Scenario 5 (whole/class discussion)	The social and cultural aspect of the NOS
	Week 8	A short evaluation of the previous week	Scenario 6 (small group – whole/class discussion)	The evaluation and tentativeness of scientific knowledge
			Scenario 7 (small group – whole/class discussion)	The values about the scientific method and results
V	Week 9	Socioscientific argumentation process (data collection – voice recording)	Scenario 8 (small group – whole/class discussion)	Energy sources used by electric and petrol cars and their environmental impacts
			Scenario 9 (small group – whole/class discussion)	Benefits and losses of mobile phones
	Week 10	Socioscientific argumentation process (data collection – voice recording)	Scenario 10 (small group – whole/class discussion)	Genetically modified organisms (GMOs)
			Scenario 11 (small group – whole/class discussion)	Advantages and disadvantages of biofuel production
	Week 11	Socioscientific argumentation process (data collection – voice recording)	Scenario 12 (small group – whole/class discussion)	Environmental impacts of nuclear power plants

FIGURE 2. *Research timeline*

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The course of argumentation analysis

For the analysis of data generated during the process of argumentation by PSTs of low, middle and high groups; these methods were followed respectively:

1. Argumentations made by the groups, which were digitally recorded with sound recorders, were written down separately according to the groups (low-middle-high) and scenarios.
2. Before starting the argumentation analysis in accordance with the argument evaluation scale, which was consisted of nine forms in total and stated above; a general template was formed in order to determine which argumentation component (*claim, data, reason, etc.)* would be chosen for which statement written in the form and in what circumstances. A researcher, expert in the field of argumentation analysis, joined to the template formation process. The compromised argument analysis method contains these premises;
   a. Provisions about certain situations were accepted as '*claim*'.
   b. If this claim was supported-explained with conjunctions or transition words like 'because, that's why'; it was accepted as '*justification*'.
   c. If the person presented the claim with a de facto knowledge, it was accepted as '*data*'. The real point considered here was words like '*for example'* and *'for instance'.* If the sentence started with these words, it was preferred to mark them as *'data'*components.
   d. If a claim stated was supported by a second justification, that second reason was marked as a '*supportive'* component.
   e. The point considered for rebuttal was the use of conjunctions like '*but, however'* that indicate contradictory or alternative aspects. If the person stated alternative or different aspects of opposite party's ideas by using a conjunction like *'but',* it was marked as a *'Rebuttal'* component. Two different ways were followed for the '*Rebuttal'* component. If the rebuttal was presented with an extra component (e.g. *data, reason, supportive)*, it was called **strong rebuttal**; it was not supported with an extra component, it was called **weak rebuttal**.
3. After reaching a consensus on the argumentation analysis method, three of the nine forms, which contain argumentations of the groups (*one form from each group*), were sent to the same researcher and the analysis made in different times and different places on these form were compared. After the comparison, reliability among coders was determined to be % 88. This value received proves the reliability of the coding (Miles & Huberman, 1994).
4. After ensuring the reliability criteria, argument component identification process was completed by conducting argumentation analysis on the rest of forms.
5. Analyzed statements in the forms were divided in to argumentation sections in order to identify argumentation quality.
6. Nine forms, which contain argumentation sections of low, middle and high group members made upon different scenarios were gathered in three forms which enabled groups to be compared.
7. Argumentation sections gathered in 3 forms were divided into levels according to the rating scale, which was developed by Erduran et al. (2004) and got ready for the quantitative analysis process.

Quantitative analysis process

In the process of quantitative analysis, quantitative data gathered were thought to be constant variables for qualitative analysis (*Level I = 1 points, Level II = 2 points, Level III = 3 points, Level IV= 4 points and Level V = 5 points*). Points obtained from data set were determined by Kolmogorov-Smirnov normality test whether they show normal distribution or not. After the normality test, in order to identify the statistical significance of the difference among low-middle-high groups' argumentation quality, Kruskal Wallis-H test was conducted.

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FINDINGS

Findings of quantitative analysis of argumentation conducted by participants of low, middle and high groups on predetermined three scenarios were presented below in Table 4.

Table 4.*Socioscientific argumentations of low, middle and high groups*

Argumentation Level	Low Group		Middle Group		High Group	
	Quantity	Score*	Quantity	Score	Quantity	Score
Level I	3	3	0	0	0	0
Level II	8	16	10	20	8	16
Level III	5	15	12	36	18	54
Level IV	6	24	6	24	13	52
Level V	3	15	4	20	17	85
TOTAL	25	**73**	32	**100**	56	**207**

*(*Score represents the number obtained by multiplying level quantity and quantitative value of the level)*

Findings presented in Table 4 indicate that Level III, IV and V, in which the best quality argumentations were made, the highest total argumentation scores attained increase from low group towards the high group. In middle and high groups, there are not any Level 1 argumentations, which include just claims, in terms of Level 4 argumentation low and middle groups compete with each other. When high group argumentations are considered in particular, it is obviously seen that they are at peak in terms of Level III, IV and V. This situation indicates that high group had a better argumentation process. On the other hand low and middle groups to have an almost same argumentation level caused not to observe a clear difference between these groups. As it is seen in Table 4, there is a significant difference between these groups only in Level III. In order to make the qualitative comparison of group argumentations, justification and strong rebuttal numbers of the groups are given in Figure 3.

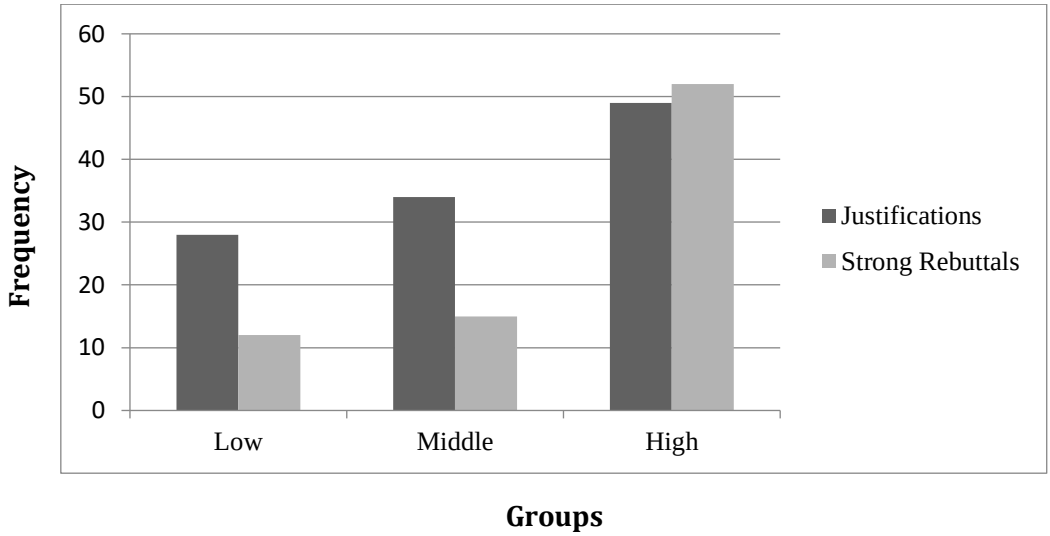

FIGURE 3.*Justifications and strong rebuttals of the groups*

Findings gathered by counting the justifications and clear rebuttals presented by the groups during the socioscientific argumentation process. It was seen that there is an increase in the number of reasons and clear rebuttals from the low group towards the high group. Accordingly, findings of Figure 3 and Table 4 seem to be alike and there is not a significant difference between argumentation quality, number of justifications and clear rebuttals of low and middle groups. For a clear understanding of the argumentations made by participants during the socioscientific argumentation process, an example for each level of argumentation was presented. Quoted

passages of PST argumentations were presented independent of the study in order to hide their identity information.

Level I Argumentation (Low Group)

This group, during Level I argumentation which was three in total, usually preferred the way to respond with a simple claim or take position with some data when they encountered with a simple claim.

> **A_L:** I wasn't to say that after all we can't produce oil in our country. As a matter of fact we have to import it.
> **B_L:** Neither electric car nor the usual gasoline car; they must find another solution.
> **C_L:** A flying car with helium gas. If there are flying balloons, why not flying cars?
> **B_L:** Anyway there was a car like that.
> **A_L:** Besides, there are LPG powered cars.

[Data (A_L) + Claim (B_L) + Claim (C_L) + Data (B_L) + Data (A_L)]

In this text, the first person presented a data set with a secret claim. The opposite party formed her/his own claim in search of a solution. Other participants tried to contribute to the discussion with claims and data.

Level II Argumentation (Middle Group)

In the middle group argumentations; Level I argument, which is the simplest argumentation that involves opposing claims, was never done. Instead of that, there was a general concentration on Level II and Level III. Most of the participants in this group usually performed argumentations that involve claim, data, justification and supporting components.

> **A_M:** I don't say cell-phones should not be used, but its use should be reduced; because sometimes people carry even two or three cell-phones at the same time. While one cell-phone is so harmful for the brain, we can't imagine how harmful a few can be. Already we have been living exposed to radiation all day.
> **B_M:** Yes, we have to use technological devices, but cell-phone is not a must. How could people communicate before cell-phones? They managed it somehow.

[Claim + Warrant + Backing (A_M)] + [Claim + Warrant (B_M)]

In this argumentation part where there is a mutual idea, the first participant reinforces her/his claim with a justification and supporting components. In response, the other participant presents a reasoned claim and shows her/his agreement.

Level III Argumentation (Middle Group)

This group's most preferred argumentation type was Level III argumentation. That this argumentation level involves claims, data, justifications and supportive components, along with weak rebuttals –even if it rarely happens- is an indication of middle group participants valuing week rebuttals in their argumentations.

> **A_M:**I think it should be used, because oil consumption results in air and water pollution. Bicycles or electric cars can be used; so that we can prevent harms caused by oil consumption.
> **B_M:** I agree with you, how right it can be to pollute water.
> **A_M:** No, you are using water; not polluting it.
> **C_M:** But, you consume it.
> **A_M:** To use electric vehicle you use energy of water cycling.

[Claim + Warrant + Backing (A_M)] + [Warrant + Claim (Latent) (B_M)] + [Rebuttal (Weak) (A_M)] + [Rebuttal (Weak) (C_M)] + [Data (A_M)]

In this argumentation part, the first participant enforces her/his claim with a justification and supportive component. The next group member presents her/his reason with a secret claim. Another participant who chooses a different perspective for the situation creates a weak rebuttal. The participant who had the final word presents data to reinforce her/his claim.

Level IV Argumentation (High Group)

For the high group it was seen that participants made a Level IV argumentation, which involves an strong rebuttal and opposing sets of claims.

C_H: All right, what if these vegetables could be used where rice is not easy to be produced.
B_H: For them GDO is used for the other vegetables.
C_H: OK, we are telling the same thing. You balance something with something else, if you don't have it.
B_H: I'm saying that... Suppose that rice can't be raised in Israel; they can get the vitamins, which they should be proving from rice, from some other genetically modified organism
A_H: We are supporting the idea that they can get those vitamins from other natural plants.
B_H: What if there is none?
C_H: It is not possible, there are so many kinds.

[Claim (C_H)] + [Claim (B_H)] + [Claim (C_H)] + [Rebuttal (Strong) + Data + Warrant (B_H)] + [Claim (A_H)] + [Rebuttal (Weak) (B_H)] + [Rebuttal (Weak) (C_H)]

In this three people conversation part, first two participants state their claims one after another. After that, the first one states another claim and the second one responds with a rebuttal supported with data and a justification. End then another participant joins and states a claim from a different perspective. The last two arguments are stated as weak rebuttals and participants skip to another part of argumentation.

Level V Argumentation (High Group)

Level V argumentation, which has all the argumentation components in a wide range and more than one strong rebuttal, was mostly made by high group participants. This shows that high group participants are more successful at creating strong rebuttals than participants of the other groups.

B_H: For instance if there hadn't been smart phones when you were born, you wouldn't need them; you would know how to live without them, but they exist.
D_H: OK, but, we don't have to go on living with them since there are phones in today's technology.
A_H: But you are used to arranging everything with your cell-phone; suppose how hard would it be, if, suddenly, you had to use letters and telegraphs again!
C_H: It shouldn't have to be suddenly, you stop using something when you have other things to substitute it.
D_H: Bui it is not a necessity like eating or drinking. You can go on living without it.
A_H: Being social and satisfying social needs are as necessary as eating or drinking. For a person being happy, talking to another person, going out with them are as important as eating and drinking.

[Claim + Warrant (B_H)] + [Rebuttal (Weak) (D_H)] + [Rebuttal (Weak) (A_H)] + [Rebuttal (Weak) (C_H)] + [Rebuttal (Strong) + Warrant (D_H)] + [Rebuttal (Strong) + Warrant + Datat (A_H)]

In this argumentation part, the first participant states a reasoned claim. The opposite party responds with a weak rebuttal. In this part, where all the participants present opposing arguments, the third participant responds with a weak rebuttal, too. The fourth participant's argument is a weak rebuttal, too. At the end, the last participant presents an strong rebuttal, so

that, this part of the argument contains more than one rebuttal and becomes a Level V argumentation.

Quantitative Comparison of Low, Middle and High Groups' Socioscientific Argumentation

Levels which were obtained with the division of PSTs', who were divided into three groups as low, middle and high, arguments were thought as a continuous variable for each section. (*e.g.; Level I = 1 points, Level II = 2 points… etc.*). By this way, each group's socioscientific argumentation scores were statistically compared and significance level of the argumentation quality among groups was evaluated. At this point, first of all, in order to see whether the data obtained during the process of socioscientific argumentation show normal distribution or not, kolmogorov-smirnov normality test was conducted on the data. As a result it was seen that the data (argumentation parts) do not show normal distribution (*p<,05*). Because the argumentation parts do not demonstrate normal distribution, the significance of the difference between PSTs' the NOS understandings and socioscientific argumentation quality was determined by Kruskal Wallis H-Test.

Table 5. *Kruskal wallis h-test results of low, middle, high groups' socioscientific argumentation scores*

Groups	N	Mean Rank	df	x^2	p
Low	25	45,80	2	9,102	0,011
Middle	32	50,06			
High	56	65,96			

p<,05

According to analysis results given in Table 5; socioscientific argumentation quality of the groups shows 0,5 degree significance differentiation in comparison to NOS understandings. [x^2 (2)= 9,102, p<0,05]. This finding revealed that there was a significant difference among the mean ranks of the groups. When mean ranks of the group are analyzed it can be seen that there is an increase from low group to the high group. In short Kruskall Wallis H-Test results showed that NOS understandings of PSTs significantly affect their socioscientific argumentation qualities.

DISCUSSION and CONCLUSION

In this study, PSTs' NOS understandings effects on their socioscientific argumentation quality was analyzed. Twenty-seven participants in total were divided into three groups according to their NOS understandings - four participants in each group- made arguments. After qualitative and quantitative analysis, it was concluded that NOS understandings of PSTs significantly affect their socioscientific argumentation qualities. Findings obtained from qualitative analysis of the study show that arguments made by the participants of high group are have much higher standard of quality than the other groups' participants (Table 5). As a result, it was concluded that argumentations of high group were much better than the other groups in terms of *total argumentation score* (Table 4), *quantity of Level III, IV and V argumentations* (Table 4), *quantity of strong rebuttals* and *reasons* (Figure 3). For instance it was confirmed that total argumentation score of high group was higher than combined total scores of the other two groups; also, Level IV and Level V argumentations –levels of best quality argumentations- were conducted more in high group than the other groups. This result indicates that participants of high group were more active than the participants of other groups in terms of forming strong rebuttals. Corroborative findings for this, which demonstrates that strong rebuttals made by high group are more than the other groups' total rebuttals, were presented in Figure 3. It also confirms that strong rebuttals are the

most important factor that determines the quality of an argumentation (Erduran et al., 2004; Kuhn, 1991; Simon, 2008).

Total argumentation score of high group, whose members were top four pre-service teachers who had the highest NOS understanding, was determined to be 207. This score's being higher than combined total argumentation scores of low and middle groups (*low group: 73, middle group: 100*) proves that NOS understanding has a significantly affects argumentation quality (e.g. Albe, 2008; Zeidler et al., 2002). Argumentations scores, higher from low to high groups, are also corroborative for this claim. In order to deeper investigate this claim, argumentations made by low and middle groups were qualitatively analyzed; and it was found that argumentation qualities of these groups were so close to each other. For example as it is stated in Table 4, it is remarkable that Level IV and Level V argumentation numbers of low group is respectively '6' and '3'; the same numbers for middle group are '6' and '4'. Likewise, total scores of these groups being so close to each other is also considered as an important finding (*low group: 73, middle group: 100*). In order to clarify whether the argumentations of low and middle groups differentiate or not clearly; their reason and strong rebuttal numbers were, also, compared independently of argumentation parts. Findings presented in Figure 3 prove that argumentations of these groups are similar to each other. According to this Figure while low group's number of reasons is 28, it is 34 for middle group; and, while low group's number of strong rebuttals is 12, it is 15 for middle group. In short when it is looked qualitatively, socioscientific argumentation quality of high group is a lot higher than argumentation qualities of low and middle groups; however, there is not a significant difference between the argumentation qualities of low and middle groups. This result obtained bears a resemblance to the findings of the study made by Sadler and Fowler (2006). These researchers, who investigated how college students use their science content knowledge, determined that; there is a significant relation between science content knowledge and socioscientific argumentation quality, for the transfer of science content knowledge to the socioscientific argumentation quality two end points (the lowest and the highest) can be effective and they named it *"Threshold Model".* The researchers claimed that the reason for the appearance of two end points in the transfer of science content knowledge was rooted in students having social complexities about the discussion content and their tendency for focusing on the same socio-cultural themes. In this study, however, it was found that socioscientific argumentation quality of high group, whose members have higher NOS understanding, was much higher than low and middle groups. On the other hand, when argumentations of low and middle groups were compared, they did not differ much from each other. This result indicates that *the Threshold Model*, which was suggested by Sadler and Fowler (2006) concerning the relation of science content knowledge and socioscientific argumentation quality, can also be valid for the relation of NOS and socioscientific argumentation quality. It is another remarkable point that there has been no study, which involves any findings like this result on the subject of the relationship between the NOS and socioscientific quality.

In order to support qualitative results that had been obtained; qualitative data were transformed to quantitative data and kruskal wallis H-test was conducted on these quantitative data. As a result of this test, which was conducted to determine the significance of the difference among the argumentation qualities of low-middle-high groups, it was determined that there had been 0,05 significant difference among the mean ranks of the groups. In terms of this result socioscientific argumentation quality gets higher from low group towards high group. When mean ranks of the groups are considered, it is seen that the situation mentioned above about low and middle groups is, also, valid here (Table 5). According to Kruskal Wallis H-Test results, average mean ranks of the groups increase from low to high group as '*45,80*'; '*50,06*' and '*65,96*'. As it is understood from the mean rank scores mentioned here; low and middle group are so close to each other as usual and high group differ from them with a much higher score. However, the significance of the difference among groups reveals that low group and middle group significantly

differ from each other. This result, which demonstrates that the socioscientific argumentation quality increases as the NOS understanding progresses, is highly compatible with the findings of similar studies that have been stated in the literature (Albe, 2008; Herman, 2015; Sadler, Chambers, & Zeidler, 2004; Zeidler et al., 2002).

In this study, for the formation of groups in terms of NOS understanding, NSAAQ test was conducted. This is a test, which was prepared in order to determine an individual's epistemological comments on; nature of scientific knowledge, methods that can be used to produce scientific knowledge, conditions in which scientific knowledge can be considered valid and reliable, and social and cultural nature of scientific knowledge. Studies, dealing with the issue of whether epistemological believes influence the degree of socioscientific argumentation, were analyzed setting forth with the idea that this test is intended to determine epistemological comments and the NOS is a component of epistemological believes (Lederman, 2007) and, also, it involves believes on the nature of knowledge. The results of this study are consistent with the findings of the mentioned studies (Liu, Lin, & Tsai, 2012; Mason & Boscolo, 2004; Mason & Scirica, 2006; Schommer-aikins & Hutter, 2002; Wu & Tsai, 2011).

There are also studies that have inconsistent results. In those studies, it was concluded that the NOS understanding did not affect the socioscientific decision making process. The factors behind the inconsistency can be listed as:

Number of participants: Bell and Lederman's (2003) study, which had inconsistent results with this study, was conducted only with 21 participants; while another inconsistent study, Walker and Zeidler's (2007), was conducted with 36 participants. On the other hand Khishfe (2012a, 2012c, 2014) in her three studies worked with 83, 45, 121 participants respectively. This study was conducted on the data of only 12 PSTs who were selected among the 27 participants. All of the five studies that had contrary result to this study were conducted with more participants than this study. This situation may be one of the factors.

Number of groups: In this study low-middle-high groups were formed according to their NOS understanding levels and their socioscientific argumentation qualities were compared; on the other hand, the other studies, in which the same results had not been obtained, were conducted with just one group. That's why it is possible that having more groups and fewer participants may be one of the factors.

Participants' grades: Third grade PSTs were the participants of this study; however, the other studies were not conducted with pre-service teachers. Bell and Lederman (2003) conducted their study with academicians; and Walker and Zeidler (2007) worked with high school students. Likewise, Khisfhe (2012a, 2012c, 2014) conducted her studies with secondary and high school students. This situation may, also, be one of the factors.

The kind of the data collection tool: For this study, in order to determine NOS understandings of the participants NSAAQ test, which was developed by Sampson and Clark (2006), was used. For the other 5 studies VNOS forms, which were developed by Lederman, Abd-El-Khalick, Bell, and Schwartz (2002), were used. The reason of developing NSAAQ test for Sampson and Clark (2006) was the inadequacy of previous tests; they were either too specific (VOSTS) or too generalized (VNOS). Unlike VNOS forms, NSAAQ was developed in order to determine an individual's epistemological comments on; *nature of scientific knowledge, methods that can be used to produce scientific knowledge, conditions in which scientific knowledge can be considered valid and reliable, and social and cultural nature of scientific knowledge.* This situation may be one of the factors.

Recommendations

The findings of this study and stated facts in the literature clarify that more studies related to this field of research should be conducted. For this reason, in order to support the literature, more studies can be conducted with PSTs without making any change in content. In addition to

this, PSTs can be supported for participating in activities about the NOS and socioscientific argumentation.

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