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Bilimin Doğasına Yönelik Görüşlerde Öğrenci Özelliklerinin Rolü

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ÖZET

Bu çalışmada, ortaokul öğrencilerinin bilimin doğasına yönelik görüşleri, kesitsel ve ilişkisel araştırma deseni kullanılarak, cinsiyet, sınıf düzeyi ve öğrenme ortamı algılarına göre incelenmiştir. Çalışmaya 7. (n=286) ve 8. (n=322) sınıflara devam etmekte olan toplam 608 ortaokul öğrencisi (319 kız ve 289 erkek) katılmıştır. Öğrencilerin bilimin doğasına yönelik görüşleri Bilimin Doğasına Yönelik Görüş Ölçeği kullanılarak Yaratıcılık/Gerekçelendirme, Değişebilirlik, Nesnel olmayış ve Teori yüklülük/Kültürel etki alt boyutlarında incelenmiştir. Öte yandan, öğrenme ortamına yönelik algılar, Bu Sınıfta Neler Oluyor Ölçeği uygulanarak Öğrenci uyumu, Öğretmen desteği, Katılım, Araştırma, Görev uyumu, İşbirliği ve Eşitlik olmak üzere toplam 7 alt boyutta ele alınmıştır. Sonuçlar, cinsiyet ve sınıf düzeyinin, bilimin doğasına görüşlerde bir fark oluşturmadığını göstermiştir. Fakat öğrenme ortamı algısına yönelik tüm alt boyutlar ile değişebilirlik alt boyutu hariç, bilimin doğasına yönelik tüm alt boyutlar arasında ilişki olduğu bulunmuştur. Sonuçlar, ilgili alanyazın göz önüne alınarak tartışılmış ve sınıf içi uygulamalar ile ileriki çalışmalar için olası doğurgular belirtilmiştir.

Anahtar Sözcükler: Bilimin doğası, öğrenme ortamı, ortaokul öğrencileri, cinsiyet, sınıf düzeyi

The Role of Student Related Characteristics in Nature of Science Views

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ABSTRACT

The present study investigated middle school students' views on the nature of science (NOS) in relation to gender, grade level, and learning environment perceptions adopting a cross-sectional and correlational research design. A total of 608 middle school students (319 girls and 289 boys) attending Grade 7 (n = 286) and Grade 8 (n = 322) participated in the study. Students' NOS views were examined in terms of Theory-laden /Cultural impacts, Changing/tentative nature, Non-objective nature, and Creative nature/Justification tenets using Students' Views of Nature of Science Instrument. Learning environment perceptions, on the other hand, were assessed using What is Happening in This Class Questionnaire, in these seven dimensions: Student cohesiveness, Teacher support, Involvement, Investigation, Task orientation, Cooperation, and Equity. According to the results, there were no gender or grade level differences with respect to students' NOS views. Findings also demonstrated that all dimensions of learning environment perceptions were related to the students' views on all NOS tenets except for changing/tentative nature. Results were discussed considering relevant literature and implications for future research and classroom practices were outlined.

Keywords: Nature of science, learning environment, middle school students, gender, grade level

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1. INTRODUCTION

Positivists argue that there is a single objective reality independent of values, attitudes, or perspectives. What is expected from scientists is to access this external reality in an objective manner (Sim & Wright, 2000). Thus, according to this view, the natural world and the relationships in it already exist and the task of scientists is just to 'discover' it. Accordingly, science is an objective activity not affected by cultural, political, social or philosophical influences and biases (Allen & Baker, 2017). It is cumulative and progresses toward the truth (Allen & Baker, 2017, Okasha, 2002). Holding an empiricist view of science, positivists also maintain that experience provides the only valid basis for knowledge. Accordingly, scientific research requires the data collected

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through senses. The concepts, propositions or any statements which could not be observed or otherwise experienced are meaningless. Their research methodology is mainly inductive which leads to the development of general propositions or laws from actual observations. Positivists also claim that there is one scientific method, which can be utilized to study both the physical world and the social world (Sim & Wright, 2000).

According to some philosophers and historians, however, the positivist view of science is naïve, and does not provide an actual representation of how science works (Allen & Baker, 2017). For example, Popper (2002) argued that scientists use their imagination and creativity to develop remarkable theories with important and wide-ranging implications. Popper further claimed that true scientists expose theories to the risk of falsification rather than trying to obtain supporting evidences (i.e. inductive proof). Thus, the community of scientists is aware of uncertainty of their knowledge (O'Hear, 1989). Additionally, Kuhn (1996) maintained that the data obtained by scientists was theory-laden. According to him, obtaining theory-neutral data free from scientists' background beliefs or theoretical commitments was not possible. Kuhn provided examples from history of science, also noted that science was not always cumulative, that is to say progressing in a linear fashion. Sometimes, old paradigms (i.e. assumptions, ideas, and methodologies prevalent in any field of science) can be replaced with new ones leading to new conceptualizations. Kuhn also pointed out the role of social context in the practice of science. He viewed science as an intrinsically social activity (Kuhn, 1996; Okasha, 2002). Considering all these views, post-positivist researchers' propositions appear to provide a more realistic picture of how scientific ideas change and how science works (Allen & Baker, 2017).

Contemporary science education researchers advocating the nature of science (NOS) as an essential component of scientific literacy identified some key tenets of NOS (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002; McComas, 2014) benefiting from these post-positivist approaches. Thus, a consensus has been reached to some extent by science educators (Deng, Chen, Tsai, & Chai, 2011). For example, according to Lederman et al. (2002), there are seven key tenets of NOS: (a) the empirical nature of scientific knowledge (b) scientific theories and laws (c) the creative and imaginative nature of scientific knowledge (d) the theory-laden nature of scientific knowledge (e) the social and cultural embeddedness of scientific knowledge, (f) myth of scientific method, and (g) tentative nature of scientific knowledge.

Among the tenets, the empirical nature of scientific knowledge involves that scientific knowledge is at least to some extent derived from the observation of natural world (Lederman, 1999). However, scientists do not always access to natural phenomena directly. Instead they make some inferences. Accordingly, students with sophisticated views on empirical nature of science should be able to discriminate between observation and inference. Such discrimination enables them to better comprehend theoretical or inferential entities (Lederman et al., 2002).

In addition, the second tenet of the NOS involves that students distinguish between scientific theories and laws and understand that they are dissimilar types of knowledge. While laws are descriptions about the relationships among observable phenomena, theories provide inferred explanations for large sets of apparently distinct observations in different fields of investigation (Lederman et al., 2002).

According to the third tenet of NOS, creativity and imagination are also important to generation of scientific knowledge. Indeed, science requires development of explanations and theoretical entities, both of which involve scientists' creativity (Lederman et al., 2002). For example, Kepler went far beyond the existing data and theorized underlying map of the heavens boldly using only inadequate or limited data. Thus, his work did not progress by simple gathering and organization of presuppositionless data (O'Hear, 1989).

While the third tenet is about the role of creativity and imagination in the development of scientific knowledge, the fourth tenet, emphasizes the theory-laden nature of scientific knowledge. According to this tenet, scientists' prior experiences, knowledge, theoretical commitments affects their work. Thus, their observations and how they interpret these observations may be shaped by their background beliefs and experiences (Lederman et al. 2002, Okasha, 2002). For example, for an Aristotelian scientist, a falling stone can be interpreted as an example for a natural motion, however for a scientist with a commitment to Newton's physics; this fall can be interpreted in terms of law of universal gravitation.

Additionally, the fifth tenet emphasizes the social and cultural embeddedness of scientific knowledge. In fact, scientific knowledge is generated in the context of a larger culture and scientists grow up within this culture. So, science is not independent of place and time which are culturally situated and affected. In general, according to this tenet, science influences and influenced by various factors including social, political, and economical factors (Allen & Baker, 2017; Lederman et al., 2002).

The sixth tenet of NOS, on the other hand, is about the myth of scientific method. There is a common misconception that there is one scientific method which all scientists follow resulting in the development of infallible knowledge. However, there is no single method such as inductive method that all scientists follow step by step. For example, Galileo did not induce laws of pendulum motion by making systematic observations of several pendulums and then making generalizations (Matthews, 2015). Rather, he used the language of mathematics. Actually, according to him, mathematics could be utilized to describe the behavior of objects in the material world. He also gave emphasis on the experimental testing of the hypotheses (Okasha, 2002).

Finally, the last tenet of NOS suggested by Lederman et al. (2002) involves tentative nature of scientific knowledge. As it has been mentioned by Lederman et al. (2002), even though the scientific knowledge, including theories and laws, is reliable and durable, it can change as new evidences are obtained. For example, Newtonian physics was considered as basically correct by scientist for a long time. However, in the initial years of the 20th century, two revolutionary developments namely, relativity theory and quantum mechanics demonstrated that Newtonian mechanics do not apply to all objects (Okasha, 2002).

The similar tenets of NOS comprising tentativeness, subjectivity, creativity, historical, cultural, and social influences were also suggested by McComas (2014). These tenets identified by the science education researchers are considered to be the most beneficial and relevant dimensions of NOS for K-12 science teaching and learning (Deng et al. 2011; Lin, Goh, Chai, & Tsai, 2013). Accordingly, researchers attempted to develop instruments to assess students' views on these core tenets of NOS: These instruments include Nature of Scientific Knowledge Scale (NSKS) (Rubba & Anderson, 1978), Views of Nature of Science (VNOS) (Lederman et al. 2002), The Pupil's Nature of Science Scale (PNSS) (Huang, Tsai, & Chang, 2005), Student Understanding of Science and Scientific Inquiry (SUSSI) (Liang et al. 2008), Views on Science and Education Questionnaire (VOSE) (Chen, 2006), Scientific Epistemological Beliefs Survey (SEBS) (Conley, Pintrich, Vekiri, & Harrison, 2004), Scientific Epistemological Views (SEVs) (Tsai & Liu, 2005), and Students' Views of Nature of Science (SVNOS) (Lin et al. 2013).

Some of the abovementioned instruments consist of open-ended questions (e.g. VNOS), so they can be used only with small samples. In the literature, they are commonly used in experimental designs and they are not appropriate for inferential statistical analyses (Martin-Dunlop, 2013). Thus, in order to obtain students' views on NOS on a larger scale and conduct inferential statistical analyses to be able to make some generalizations, Likert-type instruments are more appropriate. However, some researchers criticize the use of Likert type instruments to assess NOS views. (Abd-El-Khalick, 2014, Lederman, 2010). According to these researchers, it is not easy to assess such a complex construct by Likert type or multiple choice items. However, as pointed out by Lederman (2010), the desire for developing instruments which can be mass implemented and scored in less time consuming still remains. Accordingly, the researchers continue to attempt to develop valid paper-and-pencil instruments with Likert-type items to assess NOS views. A judicious assessment of available instrument revealed that, the items of instruments with poor validity have the following properties: 1. focus on students' skills and abilities necessary to be involved in the process of science 2. emphasize affective domain rather than understanding 3. put little or no emphasis on the development of scientific knowledge and its epistemological aspects (Lederman, 2010). Considering all these sights in the literature regarding the assessment of NOS views, in the current study, middle school students' views of NOS were aimed to be determined using a Likert-type instrument on a large scale. Among the available instruments, Students' Views of Nature of Science (SVNOS) (Lin et al., 2013) was chosen because the instrument was developed using the sub-scales or items from existing instruments targeting the main tenets of NOS including cultural impact, theory-laden nature, creative nature, non-objective nature, tentative nature, social negotiation, and justification reflecting consensus views on science. Accordingly, the items of SVNOS emphasizes NOS understanding rather than attitudes or skills and the items give emphasis on the epistemological aspects of the development of scientific knowledge Reliability and confirmatory factor analyses results also indicated that it was a valid and reliable instrument to assess middle school students' NOS views on these key tenets. In the current study, students' NOS views measured by the SVNOS were examined in relation to their gender, grade level, and learning environment perceptions as elaborated in the following section:

1.1. Students' NOS Views in relation to Gender, Grade level, and Learning Environment Perceptions

Relevant research demonstrated that students' learning experiences play an important role in the development of NOS views (Hofer, 2001; Solomon, Scott, & Duveen, 1996). According to Lederman and Druger (1985), students are likely to develop sophisticated views on NOS in the classroom environments where they are actively involved in the learning process with emphasis on inquiry oriented questions and problems. Teacher support also emerged as an important factor contributing to the development of sophisticated views.

Supporting the aforementioned finding, Martin-Dunlop (2013) reported that there were significant, positive bivariate correlations between students' understanding of NOS and their perceptions of classroom learning environments in terms of student cohesiveness, instructor support, investigation, cooperation, open-endedness, and presence of adequate material. In line with these quantitative findings, qualitative results also revealed that laboratory activities requiring an open-ended divergent approach during experimentation and cooperative relations among students were related to better understanding of NOS. In line with these findings, the author suggested that in order to help students develop sophisticated views on science, science teachers should be supportive acting as a facilitator and encourage cooperation among students. The teachers should provide their students with inquiry-oriented open-ended activities. Similarly, Solomon et al. (1996) suggested that encouraging students to design experiments, collect and analyze data can promote students' NOS views.

Accordingly, in the present study, using self-report instruments, the relation between students' learning environment perceptions and their NOS views was examined. Students' learning environment perceptions were explored in the seven dimensions: student cohesiveness, teacher support, involvement, investigation, task orientation, cooperation, and equity using 'What is Happening in This Class Questionnaire' (WIHIC) (Aldridge & Fraser, 2000).

Among the aforementioned dimensions, Student cohesiveness, involves the interactions among the students concerning how friendly and supportive they are to each other. Teacher support concerns the extent to which teachers are cooperative and supportive to their students. Involvement focuses on students' interest, enjoyment, and participation in classroom activities. Investigation involves the skills and inquiry and the extent to which students use them in problem solving and investigation. Task orientation focuses on whether students pay attention to planned activities and tasks, as well as remain on tasks and being aware of what was expected from them. Cooperation concerns to what extent students cooperate with each other while doing classroom projects or assignments. And equity involves the extent to which teachers provide students with equal opportunities to contribute to classroom activities or to receive encouragement or praise (Waldrip, Fisher, & Dorman, 2009). Waldrip et al. (2009) suggested that the WIHIC was useful for predicting various student outcomes. Accordingly, in the current study, the WIHIC was utilized to predict students' NOS views. Results provided some specific implications for science educators and teachers to design learning environments conducive to the development of sophisticated view of NOS among middle school students.

In the current study, grade level differences in students' NOS views was also examined. Related literature suggested that age related trend in students' NOS views may not always be positive depending on the learning environment that they experience (Chai, Deng, & Tsai, 2012). Thus, if students experienced learning environments emphasizing rote memorization and activities and problems with single solutions which did not require thinking in multiple directions, students' NOS views could remain naïve. Thus, grade level differences, if found, could give some clues about students' learning experiences.

In addition, researchers in the field of science education have suggested that more emphasis should be given to the exploration of gender differences in students' NOS views (Wen, Kuo, Chang, & Tsai, 2010). When the relevant literature was reviewed, it was found that research on both gender and grade level differences were inconclusive (Deng et al., 2011). For example, the study conducted by Huang, Tsai, and Chang (2005) demonstrated that males hold more sophisticated views on tentative nature and role of social negation tenets of NOS. In addition, fifth grade students were found to have more sophisticated views related to changing nature of scientific knowledge compared to sixth grade students. In another study, Hacıeminoglu, Yılmaz-Tüzün, and Ertepınar (2014) found that there was no gender difference with respect to NOS views. On the other hand, significant differences were found among sixth, seventh, and eight grade students concerning observation and inference tenet. Regarding the tentative nature of NOS, seventh grade students' responses were found to be significantly different from that of sixth and eighth grade students. No difference was found among different grade levels with respect to imagination and creativity. Thus, based on the available literature it appears that grade level differences are not consistent across different tenet of NOS. In addition, the research examining gender difference was found to produce mixed results. Thus, more research is needed in order to clarify the students' NOS views in relation to gender and grade level.

Indeed, conducting studies on students' NOS views is important because studies in the relevant literature demonstrated that students' views on NOS play an important role in their knowledge acquisition, their approaches to learning science and their reasoning and argumentation (Deng et al. 2011; Lederman, 1992; Sadler, Chambers, & Zeidler, 2004). More specifically, according to results, students with sophisticated views on NOS were likely to use learning strategies leading to meaningful learning and have favorable attitude toward science (Tsai & Liu, 2005). Thus, in order to improve students' science learning and performance as well as science education in general, there is a need for determining students' NOS views and how these views are related to their demographics and learning environment perceptions. Accordingly, current study aims at examining middle school students' NOS views in relation to their gender, grade level, and learning environment perceptions. More specifically, this study addresses following research questions:

1) Are there gender and grade level differences with respect to middle school students' NOS views?
2) Are there relationships between middle school students' classroom environment perceptions and their NOS views?

2. METHODOLOGY

2.1. Participants

A total of 608 middle school students (n = 286 Grade 7 and n = 322 Grade 8) from four public schools, participated in the study. Of the 608 students, 319 (52.5 %) were Girls and 289 (47.5 %) were Boys. The participants ranged in age from 13 to 15 with a mean age of 13.59 (SD = .55). The mean of the participants science report grade from the previous semester was 4.30 out of 5 (SD = .86). A great majority of participants' mothers (89.9 %) and fathers (79.5 %) had a high school or lower degree. While approximately 20 % of the fathers had a university degree, only 10 % of mothers graduated from a university. There were no students with parents having M.S. degree. About 69 % of participants' mothers were unemployed. On the other hand, almost 90 % of the fathers were employed. Less than half of the participants were from families with 3 children (42.3 %). Only 4.8 % of the participants were single child. More than three-quarter of the participants had their own study room (89. 8 %), a computer (84.2 %), and Internet access (77.5 %) in their homes.

During sample selection, cluster random sampling integrated with convenience sampling was utilized. The districts to conduct the study were selected using convenience sampling. Then, public schools considered as clusters were randomly selected from the districts.

2.2. Instruments

2.2.1. Students' Views of Nature of Science Instrument (SVNOS)

The SVNOS was constructed by Lin et al. (2013) to assess middle school students' views of nature of science using the items and scales from existing instruments (Tsai & Liu, 2005; Chai et al., 2010; Conley et al., 2004). It consists of 33 items in seven sub-scales: cultural impacts (n = 4 items, e.g. "Scientific knowledge is the same in various cultures"), theory-laden (n = 6 items, e.g. "Scientists' research activities will be affected by their existing theories"), creative nature (n = 4 items, e.g. "Creativity is important for the growth of scientific knowledge"), non-objective nature (n = 5 items, e.g. "Scientists always agree about what is true in science"), changing/tentative nature (n = 3 items, e.g. "Ideas in science sometimes change"), social negotiation (n = 5 items, e.g. "Valid scientific knowledge requires the acknowledgment of scientists in relevant fields"), and justification (n = 6 items, e.g. "Good answers are based on evidence from many experiments"). The items were on a five-point Likert scale ranging from 1= strongly disagree to 5 = strongly agree. Factor structure of the SVNOS was validated through confirmatory factor analysis (CFA) with following fit indices: χ^2 /df = 2.33, RMSEA = .062, CFI = .98, NFI = .97, NNFI= .98, and GFI = .84. In addition, sub-scale reliabilities were found to range from .77 to .93. To be able to use the SVNOS in the current study, necessary permission was obtained from the developers of the instrument.

In the present study, in order to validate the SVNOS for Turkish middle school students, it was first translated into Turkish by the first author. The translated version was examined by two professors in science education familiar with NOS research for content validity. Turkish version of the SVNOS items were also examined for clarity, comprehensiveness, and sentence structure by the professors. In addition, an expert in an Academic Writing Center checked for the appropriateness of the translation and a Turkish language teacher examined the translated items in terms of their appropriateness for Turkish grammar and language structure. Moreover, to determine whether the items are easily understood by middle school students, their opinions regarding the clarity of the items were obtained having them read the translated items. In the current study, back translation method was not utilized since it is very probable that even though back translation is good, the original translation may be of low quality, leading to non-equivalent items. Moreover, the errors in the original translation can be replicated in back translation. While doing back translation, translators may make "insightful guesses" to make the item, comparable to the source item even if it might not be (Hambleton & Bollwark, 1991). Accordingly, in the current study, translated version was examined by science education professors, language experts, and students. After making necessary revisions and adaptations based on their suggestions, Turkish version of the SVNOS was pilot tested with 175 Grade 7-8 students. The CFA results did not provide a good model fit (χ^2 /df = 1.63, RMSEA = .060, CFI = .89, NFI = .78, NNFI= .88, and GFI = .79). In addition, reliability coefficients were, in general, low ranging from .27 to .77. Deletion of 2 items from cultural impacts, 1 item from creative nature, 2 items from theory-laden nature, and 1 item from non-objective nature led to an improvement in internal consistencies. In addition, deletion of these items resulted in better CFA indices (χ^2 /df = 1.52, RMSEA = .055, CFI = .94, NFI = .84, NNFI= .93, and GFI = .84). However, high phi-coefficients found among creative nature, social negotiation, and justification sub-scales suggested linear dependency. In addition, although there was an increase in reliability coefficients of corresponding sub-scales after item deletion, they were still low. Thus, these items except for the item from creative nature were decided to be revised and reworded. Negative items were stated as positive items.

After making necessary revisions, final version of the instrument was examined by two professors in science education in order to ensure that, the items still assess the intended constructs. Then, the instrument was again administered to a new sample of Grade 7-8 students. Results indicated a good model fit (χ^2 /df = 3.17, RMSEA = .057, CFI = .93, NFI = .90, NNFI= .93, and GFI = .88). However, phi coefficients around 1 suggested linear dependency among some sub-scales. In addition, reliability coefficients were found to range from .48 to .77. Deletion of 2 items from the non-objective nature sub-scale led to an increase in the in this sub-scale. After deleting these 2 items, CFA was again conducted. Although there was an improvement in fit indices linear dependency problem still continued. Thus, creativity, social negotiation, and justification sub-scales, found to be highly correlated with each other, were decided to be merged considering them to measure the same construct. This new factor was named as creative nature/justification. Similarly, cultural impacts and theory-laden nature sub-scales were merged and named as changing/tentative nature. The rationale behind assigning these names and merging these sub-scales are further elaborated in the Discussion section. After making these adjustments in the factor structure, a new CFA was performed to check 4-factor structure of the SVNOS (i.e. theory-laden /cultural impacts, changing/tentative nature, non-objective nature, creative nature/justification). Results indicated a good model fit. However, two items from theory-laden /cultural impacts factor were found to have low loadings. After removing these two items, CFA results revealed following fit indices indicating a good model fit: χ^2 /df = 2.40, RMSEA = .046, CFI = .96, NFI = .93, NNFI= .96, and GFI = .91. Thus, results supported 4-factor structure of SVNOS (see Appendix A). Reliability coefficients were .70 for theory-laden /cultural impacts, .56 for changing/tentative nature, .64 for non-objective nature, and .84 for creative nature/justification. Reliability coefficients exceeding the criterion (Cronbach's alpha ≥ .55) suggested by (Hatcher & Stepanski, 1994) suggested that reliabilities were high enough to conduct further analyses.

2.2.2. What is Happening in This Class Questionnaire (WIHIC)

The WIHIC was used to assess middle school students' learning environment perceptions. It was originally developed Fraser, Fisher and McRobbie (1996) as a 90-item instrument. The 56-item version, used in the present study, was validated by Aldridge and Fraser (2000) conducting principle factor analysis and reliability analyses. The items are on a 5-point Likert scale ranging from 1 (never) to 5 (always). The WIHIC consists of 7 sub-scales: student cohesiveness (n= 8 items, e.g."I work well with other class members"), teacher support (n= 8 items, e.g."The teacher takes a personal interest in me"), involvement (n= 8 items, e.g."I explain my ideas to other students"), investigation (n= 8 items, e.g."I carry out investigations to test my ideas"), task orientation (n= 8 items, e.g. "I know how much work I have to do") cooperation (n= 8 items, e.g."I cooperate with other students when doing assignments work") and equity (n= 8 items, e.g."I have the same amount of say in this class as other students"). Cronbach's alpha coefficients ranged from .81 to .93 for individual level. The WIHIC was translated and adopted to Turkish by Çakıroğlu, Telli and Brok (2006). The same factorial structure with the original version was observed for the Turkish sample. In addition, reliability analyses indicated reasonable internal consistencies with Cronbach's alpha coefficients ranging from .75 to .88.

The CFA conducted in the present study supported the 7-factor structure of the WIHIC (χ^2 /df = 2.70, RMSEA = .054, CFI = .98, NFI = .96, and NNFI= .97). Reliabilities were .82 for student cohesiveness, .79 for teacher support, .79 for involvement, .88 for investigation, .84 for task orientation, .86 for cooperation, and .89 for equity.

2.3. Procedure

In the current study, participants were informed about the research and how to complete the data collection instruments. They were also ensured that their responses to the instruments would be kept confidential and would not have any effect on their grades in any way. The instruments were administered during regular class hours (40 minutes).

3. FINDINGS

3.1. Descriptive Statistics

3.1.1. Middle School Students' NOS Views

Descriptive statistics concerning students' gender and grade level were summarized in Table 1 and Table 2, respectively.

Table1.
Descriptive statistics across gender

	Girls		**Boys**	
Variables	**M**	**SD**	**M**	**SD**
Theory-laden /Cultural impacts	3.64	.58	3.55	.63
Changing/tentative nature	3.42	.80	3.36	.79
Non-objective nature	3.86	.24	3.89	.24
Creative nature/Justification	3.79	.60	3.66	.62

As shown in Table 1 and Table 2, all mean scores on NOS tenets were greater than mid-point of the 5-point Likert scale and comparable across both genders and grade levels. These findings imply that middle school students' views on NOS were not naïve concerning all NOS tenets. However, the mean scores also suggested that students' views were not highly sophisticated either: There was no mean score around 5 as there were none exceeding 4. According to these results, middle school students appeared to agree, although not at high levels, with the views that scientific knowledge is changeable, scientists' work is affected by their theoretical commitments, beliefs, and experiences as well as the cultural influences, creativity plays an important role in the development of scientific ideas, and justification of scientific ideas involve experimentation and social negotiation.

Table 2.
Descriptive statistics across grade level

	Grade 7		**Grade 8**	
Variables	**M**	**SD**	**M**	**SD**
Theory-laden /Cultural impacts	3.59	.60	3.60	.61
Changing/tentative nature	3.43	.81	3.36	.78
Non-objective nature	3.87	.24	3.88	.25
Creative nature/Justification	3.75	.61	3.70	.61

3.1.1. Middle School Students' Learning Environment Perceptions

In this study, the data from both genders and Grade 7 and Grade 8 students concerning their learning environment perceptions were examined as a whole, because, no gender or grade level difference was found with respect to this variable. Descriptive statistics related to students learning environment perceptions based on whole data are displayed in Table 3. As shown in the table, the highest mean score belongs to task orientation sub-scale with a mean of M = 4.20. This finding suggests that students are likely to pay attention to activities and try to accomplish them in science classes. On the other hand, the lowest mean scores were found to belong to teacher support and investigation subscales. Although, the mean scores were above the mid-point of the 5-point Likert scale for these two dimensions, perceived teacher support and the extent of carrying out investigations in sciences classes appeared to be at moderate levels. The same situation was true for cooperation and involvement sub-scales as well. Students' perceptions of student cohesiveness and equity seemed to be at relatively higher levels.

Table 3.
Descriptive statistics for learning environment perceptions

Variables	M	SD
Student cohesiveness	3.89	.75
Teacher support	3.57	.91
Involvement	3.66	.83
Investigation	3.58	.88
Task orientation	4.20	.72
Cooperation	3.62	.84
Equity	3.86	.90

3.2. Inferential Statistics

3.2.1. Multivariate Analysis of Variance

A two-way multivariate analysis of variance (MANOVA) was performed to examine gender and grade level effects on students' views on different tenets of NOS (i.e., theory-laden /cultural impacts, non-objective nature, changing/tentative nature, and creative nature/justification). Prior to the analysis, underlying assumptions of MANOVA were checked and it was found that the homogeneity of variance-covariance matrices (Box's M = 22.85, $p > .05$) assumption was satisfied. Examination of skewness and kurtosis values, mahalanobis distances, standardized scores, and bivariate correlations suggested that normality, absence of outliers and multicollinearity assumptions were also met. Scatter plot also provided evidences for linearity.

After checking the assumptions, MANOVA was carried out. In order to control for Type I error, adjustment was made in alpha level, and results were evaluated against new alpha level of .0125 obtained by dividing alpha level of .05 by number of dependent variables which was 4. Results showed that there were no significant main effects of gender (Wilk's lambda = .982, $F(4, 581) = 2.62$, $p > .0125$) and grade level (Wilk's lambda = .994, $F(4, 581) = .948$, $p > .0125$). In addition, interaction effect was not significant (Wilk's lambda = .997, $F(4, 581) = .389$, $p > .0125$).

3.2.2. Canonical Analysis

A canonical correlation analysis was conducted between the set of learning environment variables and the set of NOS views variables. Before carrying out the analysis, underlying assumptions of normality, linearity, homoscedasticity, absence of outliers, multicollinearity assumptions were checked. No serious violations of the assumptions were found as revealed by examination of skewness and kurtosis values, mahalanobis distances, standardized scores, bivariate correlations, and scatterplots. Table 4 presents bivariate correlations among the variables.

Table 4.
Correlations of the measured variables

Variables	1	2	3	4	5	6	7	8	9	10	11
1. Student cohesiveness	1										
2. Teacher support	.47**	1									
3. Involvement	.56**	.63**	1								
4. Investigation	.44**	.48**	.65**	1							
5. Task orientation	.44**	.46**	.50**	.55**	1						
6. Cooperation	.59**	.42**	.53**	.56**	.51**	1					
7. Equity	.45**	.53**	.55**	.54**	.62**	.64**	1				
8. Theory-laden / Cultural impacts	.20**	.19**	.23**	.23**	.28**	.20**	.21**	1			
9. Changing / tentative nature	.09*	.09*	.19**	.09*	.07	.12**	.11**	.31	1		
10. Non-objective nature	.-.03	.03	.05	.01	.14**	-.05	.08	.08*	.05	1	
11. Creative nature/Justification	.22**	.19**	.22**	.20**	.34**	.18**	.20**	.75**	.34**	.17**	1

*Note. * p < .05. ** p < .01*

The canonical correlation analysis results showed that the first canonical correlation was .37 (14% overlapping variance). The first canonical variate accounted for the significant relationships between the two sets of variables. With all four canonical correlations included $\chi^2(28) = 120.004$. Data on the first canonical variate is presented in Table 5 and displayed as a path diagram in Figure 1. As demonstrated in the table and the figure, with a cutoff correlation of 0.30 (Tabachnick & Fidell, 1996), all the variables in the learning environment set were correlated with the first canonical variate The first canonical variate was positively associated with all these variables. Similarly, all NOS views variables, except for tentative were positively correlated with the first canonical variate.

Table 5.
Correlations and standardized canonical coefficients

	First Canonical Variate	
Variables	**Correlation**	**Coefficient**
Learning environment variables		
Student cohesiveness	.54	.17
Teacher support	.51	.00
Involvement	.60	.19
Investigation	.54	.04
Task orientation	.97	.96
Cooperation	.42	.22
Equity	.57	.04
NOS views variables		
Theory-laden / Cultural impacts	.79	.22
Changing/tentative nature	.19	.16
Non-objective nature	.41	.26
Creative nature / Justification	.95	.80
Canonical correlation	.37	

The first pair of canonical variates showed that as students perceive the learning environment in their science classes as teacher supportive, cooperative, emphasizing investigation and active student involvement, providing equal opportunities to express ideas, and supporting student cohesiveness, they tend to hold more sophisticated views on all tenets of NOS except for tentativeness. More specifically, these students appeared to have a better understanding of the role of social and cultural influences as well as scientists' theoretical commitments, experiences, and expectations in the scientific practice. They also appeared to hold more sophisticated view about non-objective nature of science, the role of experimentation, and scientific community in the justification of scientific ideas, and the role of creativity in the development of scientific knowledge.

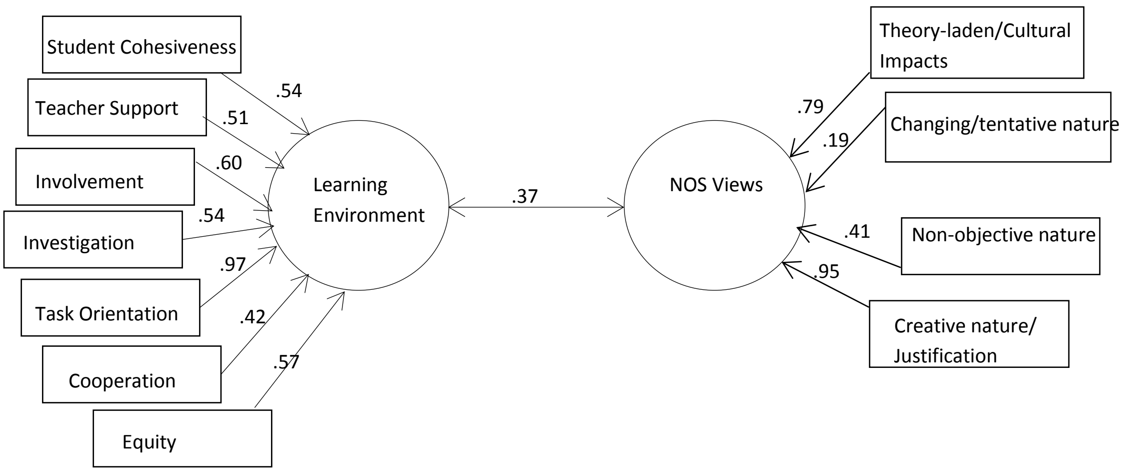

Figure 1. The path diagram for the first canonical variate

4. DISCUSSION AND RECOMMENDATIONS

In the current study, middle school student' views of nature of science were investigated in relation to their gender, grade level, and classroom environment perceptions. Students' NOS views were explored using the SVNOS constructed by Lin et al. (2013). Original version of the SVNOS consists of 33-items in 7 sub-scales (i.e., cultural impacts, theory-laden, creative nature, non-objective nature, changing/tentative nature, social negotiation, and justification.

However, in the current study, 4-factor structure provided a good fit with reasonable internal consistencies. At this point it is important to note that the original version of VNOS was developed using the items and scales from existing instruments (Tsai & Liu, 2005; Chai et al., 2010; Conley et al., 2004). In the present study, consistent with the study of Chai et al. (2010), consolidation of theory-laden and cultural impacts sub-scales into a single factor resulted in a better model. In addition, according to the results, creative nature, social negotiation, and justification were highly correlated suggesting that they all measure the same construct. Thus, these 3 sub-scales were also merged and considered as a single factor. This factor was named as creative nature/justification. Social negotiation was not included in the factor name, because it was considered as a part of justification: As indicated by Hodson (1991), scientific knowledge is produced as a result of a complex social activity leading to and following individual attempts of discovery or creation. Thus, an individual scientists' confidence in new experimental findings or new theoretical propositions is not adequate to launch it as a part of the body of scientific knowledge. It must be subject to confirmation by other researchers (Allen & Baker, 2017). In sum, in the current study, SVNOS was used in four dimension namely, theory-laden and cultural impacts, non-objective nature, changing/tentative nature, and creative nature-justification.

Descriptive findings concerning students NOS views as measured by the SVNOS suggested that middle school students' NOS views were not highly sophisticated. This finding was consistent with relevant literature (Khishfe & Abd-El Khalick, 2002; Akerson & Donnelly, 2010). According to the studies, science textbooks may be one of the reasons why students fail to develop highly sophisticated NOS views (Bell, 2004; Irez, 2009; Abd-El-Khalick, Waters & Le, 2008; Izci, 2017). For example Izci (2017) investigated the appropriateness of 7th grade science textbooks to the curriculum objectives about NOS aspects such as empirical, tentative, inferential, creative, theory-laden, social and cultural embeddedness of science, nature of theories and laws. Findings showed that scientific theories and laws aspect was not mentioned in the textbooks. Also, inferential and theory-laden aspects were not directly addressed but these aspects were implicitly mentioned. Some middle school science education textbooks were not suitable for students to develop sophisticated views about NOS. The second reason for the students' inadequate NOS views may be parents' education level. For example, Yankayış et al. (2014) examined middle school students' understanding of NOS according to demographic variables such as grade level, academic achievement and educational level of parents. The findings revealed that NOS views significantly differ among students having parents with different educational level. In addition, students of teachers who have inadequate NOS views were found to have NOS views which are not highly sophisticated. What is more, the related studies showed that teachers tend to hold inadequate NOS views as well (Akerson et al., 2000; Akerson & Hanuscin, 2007; Köksal & Çakiroglu, 2010). For example, Köksal and Çakiroglu (2010) examined science teachers' understanding of NOS concepts and findings revealed that science teachers held naïve understanding of some NOS aspects such as relationship between theory and law, but teachers held more sophisticated understanding on creativity and imagination aspect. According to relevant literature, even teachers with sophisticated NOS views may not translate their views into classroom practices effectively (e.g. Akerson & Abd-El-Khalick, 2003; Lederman, 1999). In the current study, although the students' views on nature of science were not highly sophisticated on all NOS tenets, their views were not highly naïve either. Considering aforementioned national and international literature, and context of this study, these three factors, namely science textbooks, parents' educational level, and science teachers' NOS views, all, are likely to be influential in the present findings. In the present study, for example, there were no students with parents having M.S. or Ph.D. degree. Only 10 % of the mothers had bachelor degree. Thus, one of the factors which may be related to the current finding that students' NOS views were not highly sophisticated may be parents' educational level. Accordingly, it is suggested that future studies examine the role of such factors in students' NOS views in detail. More specifically, in future research, considering the nested structure of possible data, hierarchical linear modeling (HLM) analyses can be conducted to examine students' NOS views in relation to their science teachers' views. Parents educational level can be used as covariate. The observed relations can also be tried to be explained by examining textbooks in terms of their emphasis on NOS aspects. When such potential factors influencing students' NOS views are examined in one study using appropriate analyses, the error variance can be reduced enhancing validity of the interpretations.

Examination of middle school students' views on NOS with respect to gender and grade level using the SVNOS revealed that there were no significant gender and grade level differences. As pointed out by Deng et al. (2011), the relevant research concerning gender and grade level differences produced inconclusive results: some studies revealed significant gender and grade level differences with respect to some of the dimensions of NOS (e.g. Huang, Tsai, & Chang, 2005; Lin et al., 2013). On the other hand, some others demonstrated that there is no gender difference (e.g. Hacıeminoglu, et al., 2014) or grade level differences vary across grades (e.g. Özdem, et al., 2010).

In the present study, the non-significant grade level effect can be explained as follows: the data were collected only from Grade 7 and Grade 8 students. If students from higher or lower grade levels were also included in the sample, significant differences might have been found. Because, as indicated by Hofer (2001), students' educational experiences can be influential in the development of their epistemic beliefs. This effect may be either positive or negative. The findings of the studies exploring age-related trends in NOS views in western countries generally revealed a positive developmental trend with the increase in experience or age (Lin et al., 2013). On the other hand, Asian students seemed to demonstrate a reversed trend (Chai et al., 2012; Lin et al., 2013).

Concerning the gender difference, Pintrich (2002) proposed that if (scientific) epistemological beliefs are examined focusing on specific dimensions rather than considering it as general, holistic ways of thinking, gender differences may not emerge. Consistent with this idea, and some of the studies in the literature (e.g. Conley et al., 2004) current study revealed non-significant gender difference with respect to NOS views.

Current study also investigated the relationship between middle school students' classroom environment perceptions and their views on nature of science. Students' learning environment perceptions were measured by WIHIC. According to the results, all dimensions of the WIHIC (i.e. student cohesiveness, teacher support, involvement, investigation, task orientation, cooperation, and equity) were significantly linked to all dimensions of the SVNOS except for tentativeness. This was, in general, an expected finding because related literature suggested that specific instructional activities and behaviors implemented in a classroom greatly influence students' views on nature of science (Hofer, 2001; Lederman, 1992). The study conducted by Lederman and Druger (1985) showed that supportive learning environments emphasizing inquiry oriented instruction are likely to contribute to a better understanding of NOS.

In a more recent study, Martin-Dunlop (2013) found significant, positive bivariate correlations between students' understanding of NOS and positive classroom learning environments supporting student cohesiveness, instructor support, investigation. cooperation, open-endedness, and presence of adequate material. Qualitative results also indicated that in classroom environments where students cooperate with each other and deal with laboratory activities requiring open-ended divergent approach during experimentation were linked to better understanding of NOS. Thus, the positive links found in the current study, between sophisticated NOS views and favorable learning environment perceptions; revealing the emphasis on active student involvement, open-ended investigations, task orientation, student cooperation, treating all students equally, and teacher support; are consistent with available literature.

Actually, due to abstractness of NOS, it may be difficult for students to develop sophisticated views on NOS in classroom environments where memorization and laboratory activities focusing on divergent thinking are emphasized (Martin-Dunlop, 2013). Indeed, the study conducted by Chai et al. (2012), suggested an important finding that the influence of learning environment may not be always conducive to the development of sophisticated views of NOS depending on students' classroom experiences.

Thus, based on the current findings, supporting available literature, science teachers are advised to create student-centered learning environments where students are actively involved in open ended tasks working in cooperative groups. In order to keep students on task, the activities should be interesting and evoke their curiosity. In addition, during their investigations, students should be able to feel that they have equal opportunities to express their ideas. During all these processes, teachers should be supportive. While designing the instruction in line with these suggestions, science teachers can benefit from history of science. As pointed out by Matthews (2015), history of science can be useful for science teachers suggesting them questions and experiments conducive to development of more sophisticated view of NOS. For example, students can re-do the original experiments and apart from discussing their own findings, they can be encouraged to consider historical elucidations and discussions about the experiments (Matthews, 2015). In this way, they can better understand the tenets of nature of science including theory-laden nature, social negotiation, cultural impacts, creativity, tentativeness, justification, and non-objective nature.

At this point it is important to note that as argued by Hodson (1991), science education mainly emphasizes attainment and comprehension of scientific concepts and theories and a general gratitude to scientific methods and processes. However, relatively less attention is given to the role of creativity in formulating hypotheses and designing experiments, and even less to role of social negotiation. Indeed, Lederman (1999) found that high school biology students assign limited roles to creativity imagination, and subjectivity in the development of science. The author concluded that as a starting point, students should be involved in scientific inquiry but they should also be provided with opportunities to make discussions and reflections about their investigations making nature of science more explicit. Similarly, Moss (2001) concluded that without making NOS explicit, implementing project-based and hands-on science courses were not sufficient to change students' NOS views. In addition, in more recent research, McComas and Noushin (2016), reported that there is a lack of or little emphasis of Next Generation Science Standards (NGSS) on some commonly suggested NOS aspects including creativity and subjectivity. Thus, while delivering the instruction designed to improve students view on NOS, science teachers should be careful about these issues employing explicit-reflective approach. For example, while discussing the historical cases, students should be encouraged to realize that socio-cultural influences are important in the development and justification of scientific ideas.

It is also worth mentioning that, in the current study, the relation between students' learning environment perceptions and their views on tentative nature of science was found to be non-significant. This finding is important because, based on the aforementioned literature, a positive relation was expected. Thus, this finding suggest that classroom environments emphasizing cooperation among students, teacher support and open-ended activities do not always contribute to all aspects of NOS understanding. One explanation for non-significant finding may be that the tentative nature of science might not have emphasized well in the classroom. The activities might have carried out as if the goal is to come up with the right answer. Another explanation may be that some students may think that scientific knowledge is produced as a result of rigorous scientific activity and their investigations in the classroom may not reflect this rigorous activity well. In other words, they may have a thought that as 'naïve scientists' it may not be unusual for them to change their ideas based on new evidences. On the contrary, they may also think that, because the scientific knowledge requires rigorous scientific activities of 'real' scientists, it is not likely to change. If this is the case, again integrating historical cases to science instruction making the tentative nature of science explicit may be helpful. However, the explanation provided regarding the non-significant relation between learning environment perceptions and tentative nature of NOS is speculative and warrants further research involving qualitative data collection procedures.

In sum, current findings suggested that middle school student' NOS views are related to their classroom environment perceptions but not their gender or grade level. Although, based on the results, this study provides some explicit suggestions about how science classes can be structured so that students acquire a better understanding of nature of science, there are a few limitations that should be addressed in future studies: in the present study, Likert type, self-report scales were utilized as data collection instruments to be able to access a larger sample size leading to more generalizable results. However, although self-report instruments allow researchers to access more participants, and obtain more generalizable findings, the participants' responses may not truly reflect their actual views or perceptions. Thus, in future studies, qualitative data collection techniques such as observations and interviews can be used to ensure validity of the findings and to examine students NOS views and classroom environments they experience in detail. For example, classroom observation and interviews with students and their teachers can provide a clearer picture of the relation between these two variables. In addition, regarding the psychometric properties of the SVNOS, the reliability coefficient of tentativeness sub-scale, although it was greater than the criterion suggested by Hatcher and Stepanski (1994), was relatively low. Because reliability is affected by the number of items, in the future studies, additional items can be constructed to improve the reliability of this sub-scale. Moreover, as it has been stated before, although, in the current study, data concerning participants' background characteristics were collected and gender and grade level were included in analyses, in the future research, other potential variables which may be related to students NOS views such as parents' educational level and science teachers' NOS views can be examined simultaneously to enhance the validity of the interpretations.

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Research and Publication Ethics Statement

This paper is complied with research and publication ethics.

Contribution Rates of Authors to the Article

Ebru Ebren Kuyumcu: Data Collection, Data Analysis, Writing- original draft, Writing –reviewing & editing. Semra Sungur: Conceptualization, Methodology, Data Analysis, Writing –reviewing & editing.

Statement of Interest

There is no conflict of interest to declare.

6. GENİŞ ÖZET

Bu çalışma ortaokul öğrencilerinin bilimin doğasına yönelik görüşlerini, cinsiyet, sınıf düzeyi ve sınıf ortamı algılarına göre incelemeyi hedeflemektedir. Çalışmaya 608 ortaokul öğrencisi (319 kız ve 289 erkek) katılmıştır. Katılımcıların, 286'sını 7. sınıf öğrencileri oluştururken, 322'sini 8.sınıf öğrencileri oluşturmuştur. Katılımcılara, Bilimin Doğasına Yönelik Görüş Ölçeği (Lin, Goh, Chai, & Tsai, 2013) ile Bu Derste Neler Oluyor Ölçeği uygulanmıştır (Aldridge & Fraser, 2000). Bilimin Doğasına Yönelik Görüş Ölçeği'nin orijinal formu, teori yüklülük, kültürel etki, değişebilirlik, nesnel olmayış, yaratıcılık, gerekçelendirme ve sosyal uzlaşma olmak üzere toplam 7 boyuttan oluşurken, bu çalışmada yapılan psikometrik incelemeler, ölçek için 4-faktör yapısını desteklemiştir. Bu faktörler, teori yüklülük/kültürel etki, değişebilirlik, nesnel olmayışı ve yaratıcılık/gerekçelendirme alt boyutları olarak ortaya çıkmıştır. Bu Derste Neler Oluyor Ölçeği'nde ise orijinal formuyla uyumlu olarak 7 faktörlü yapı desteklenmiş ve ortaokul öğrencilerinin sınıf ortamına yönelik algıları, öğrenci uyumu, öğretmen desteği, katılım, araştırma, görev uyumu, işbirliği ve eşitlik alt boyutlarında incelenmiştir. Cinsiyet ve sınıf seviyesi etkisini incelemeye yönelik olarak yapılan, çok değişkenli varyans analizi (MANOVA) sonuçları, cinsiyet ve sınıf seviyesinin, ortaokul öğrencilerinin, bilimin doğasına yönelik görüşleri üzerinde bir etkisi olmadığını göstermiştir. Ayrıca, bu iki değişken arasında herhangi bir etkileşim de bulunmamıştır. İlgili literatür incelendiğinde, kimi çalışmalarda herhangi bir cinsiyet (Hacıeminoglu, et al., 2014) ya da sınıf seviyesi (Özdem, et al., 2010) farkı bulunmazken, kimi çalışmalarda ise cinsiyet ya da sınıf seviyesi bulunmuştur (Huang, Tsai, & Chang, 2005; Lin et al., 2013). Pintrich'e (2002) göre, eğer öğrencilerin bilimsel bilginin doğasına yönelik görüşleri belli alt boyutlara odaklanarak araştırılır, bütüncül bir yaklaşımla incelenmezse, cinsiyet farkı bulunamayabilir. Bu düşünceye destekler niteikte, bu çalışmanın sonuçları ve literatürdeki bilimin doğasını alt boyutlar bazında inceleyen bazı çalışmalarda (örn. Conley et al. 2004) cinsiyet farkı bulunmamıştır. Sınıf seviyesi farkının bulunduğu çalışmalarda da, genel olarak, batı ülkelerinde yaş ya da sınıf seviyesi arttıkça, bilimin doğasına yönelik görüşlerin daha sofistike olduğu (Lin et al., 2013), Asya ülkelerinde ise, tersi bir durumun gozlemlendiği (Chai et al., 2012; Lin et al., 2013) ortaya çıkmıştır. Hofer (2001)'e göre, öğrencilerin, bilimsel bilginin doğasına yönelik görüşleri sınıf içi deneyimlerinden etkilenebilir. Literatürdeki bulgular ve Hofer'in görüşü gözönüne alındığında, bu çalışmada sınıf seviyesinin, öğrencilerin bilimin doğasına yönelik görüleri üzerinde bir fark oluşturmamasının sebebi, çalışmada sadece 7. ve 8. sınıf öğrencilerinin yer alması olabilir. Eğer, daha geniş bir aralıkta farklı sınıf seviyeleri çalışmaya dâhil olmuş olsaydı, bir fark gözlemlenebilirdi. Bu çalışmada, 7. ve 8. sınıf öğrencileri arasında sınıf ortamı algıları arasında bir fark bulunmamıştır.

Öte yandan, ortaokul öğrencilerinin sınıf ortamı algısı ile bilimin doğasına yönelik görüşleri incelendiğine, kanonik korelasyon analizi sonuçları, sınıf ortamına yönelik tüm alt boyutlar (öğrenci uyumu, öğretmen desteği, katılım, araştırma, görev uyumu, işbirliği ve eşitlik) ile, değişebilirlik alt boyutu hariç tüm bilimin doğasına yönelik görüş alt boyutları arasında anlamlı bir ilişki olduğunu göstermiştir. Bu sonuçlar genel olarak ilgili literatürü desteklemektedir. İlgili literatüre göre, öğretim etkinlikleri ve davranışlarının öğrencilerin bilimin doğasına yönelik görüşleri üzerinde önemli etkileri bulunmaktadır (Hofer, 2001; Lederman, 1992). Örneğin, Lederman ve Druger (1985) tarafından yapılan çalışma, araştırma, sorgulamaya yönelik, sınıf ortamlarının öğrencilerin bilimin doğasını daha iyi anlamalarına katkı sağladığı bulunmuştur. Martin-Dunlop tarafından 2013 yılında yapılan çalışma da sınıflarda öğrenci uyumu, öğretmen desteği, araştırma, işbirliği, açık uçluluk, yeterli malzemenin olması gibi faktörlerle, bilimin doğasının anlaşılması arasında pozitif ilişki bulunmuştur. Nitel veriler de bu bulguları desteklemiş ve öğrencilerin birbirleriyle işbirliği içerisinde açık-uçlu ve çok yönlü düşünmeyi gerektiren laboratuvar etkinlikleri üzerinde çalıştığı sınıf ortamlarında, bilimin doğasını daha iyi anladıkları ortaya konmuştur. Martin-Dunlop'a göre, bilimin doğası öğrenciler için soyut bir kavram olduğu için, ezber ve yakınsak düşünmeye yönelik etkinlikler, bilimin doğasının anlaşılmasını güçleştirebilir. Chai et al. (2012) tarafından da belirtildiği gibi yapılan etkinliklere bağlı olarak, sınıf içi ortamlar, her zaman öğrencilerin bilimin doğasına yönelik görüşlerine olumlu katkı sağlamayabilir.

Dolayısıyla, bu çalışmanın sonuçları doğrultusunda, öğretmenlerin, öğrencilerin etkin olduğu, açık-uçlu etkinliklerle, arkadaşlarıyla işbirliği içerisinde yer aldığı öğrenci merkezli sınıf ortamları oluşturmaları tavsiye edilmektedir. Öğrencilerin, etkinlikler/ödevler üzerinde çalışmalarının devamlılığını sağlayabilmek için, etkinlikler, ilginç olmalı ve merak uyandırmalıdır. Öğrenciler, kendi düşüncelerini ifade etmede özgür hissetmeli ve tüm bu süreçlerde öğretmen gerekli desteği sağlamalıdır. Bu noktada, öğretmenleri bilim tarihini derslerine entegre etmesi tavsiye edilebilir. Örneğin, öğrenciler, bilim insanları tarafından daha önce yapılan deneyleri tekrarlayabilir ve elde edilen bulguları tartışmanın yanı sıra, yapılan deney hakkında tarihsel olarak yapılan açıklamalar ve tartışmalar üzerinde düşünmeleri sağlanabilir (Matthews, 2015). Bu yolla bilimin doğasına yönelik, teori yüklülük, kültürel etki, değişebilirlik, nesnel olmayış, yaratıcılık, gerekçelendirme ve sosyal uzlaşma gibi boyutlar daha iyi anlaşılabilir. Fakat bu tarz etkinlikler yapılırken, doğrudan-yansıtıcı yöntemin kullanılması önerilmektedir (Lederman, 1999; Moss, 2001).

Sonuç olarak bu çalışma, ortaokul öğrencilerinin bilimin doğasına yönelik görüşlerinin, cinsiyet ya da sınıf düzeyleri değil, sınıf ortamı algılarıyla ilgili olduğunu göstermiştir. Bu çalışma nicel verilere dayanmaktadır. İleriki çalışmalarda, gözlem ve görüşme yoluyla nitel veriler de toplanıp, sınıf ortamı algısının bilimin doğasına yönelik görüşlerdeki rolü daha detaylı incelenebilir.

Appendix A

Yaratıcılık/gerekçelendirme

1. "Kabul gören bazı bilimsel bilgiler, insanların hayal gücünden ve önsezilerinden ortaya çıkmıştır"
2. "Yeni bir bilimsel bilgi, alandaki pek çok bilim insanı tarafından tanındığı zaman geniş çapta kabul görür"
3. "Bilimsel deneylerdeki fikirler, olayların nasıl meydana geldiğini merak edip düşünerek ortaya çıkar"
4. "Bilimsel teorilerin gelişmesi, bilim insanlarının hayal gücü ve yaratıcılığını gerektirir."
5. "Bilimsel bilginin gelişmesinin başlıca sebebi; bilim topluluğundaki görüşme, tartışma ve sonuç paylaşımıdır"
6. "Olayların nasıl meydana geldiği hakkında yeni fikirler bulmak için deneyler yapmak, bilimsel çalışmanın önemli bir parçasıdır."

7. “Bilimsel bilginin geçerli olabilmesi için, alandaki bilim insanları tarafından kabul görmesi gerekir”
8. “Bilim insanları bazen görünüşte alakasız olan birçok teoriden fikir alırlar”
9. “Bilimdeki, parlak fikirler sadece bilim insanlarından değil, herhangi birinden de gelebilir”
10. “Yaratıcılık, bilimsel bilginin gelişmesi için önemlidir”
11. “Bilim insanları, bilimsel bulguları değerlendirmek için kullanılabilecek kriterler konusunda fikir birliğine sahiptir”
12. “Bir şeyin doğru olup olmadığını anlamak için deney yapmak iyi bir yoldur”
13. “Bilimsel teoriler, bilim insanlarının aralarında yaptıkları görüşme ve tartışmalar yoluyla daha da gelişir”
14. “İyi çıkarımlar, birçok farklı deneyin sonucundan elde edilen kanıtlara dayanır”
15. “Bilimdeki düşünceler, konu ile ilgili kendi kendinize sorduğunuz sorulardan ve deneysel çalışmalarınızdan ortaya çıkabilir”

Değişebilirlik
1. “Bilimsel kitaplardaki bilgiler bazen değişir”
2. “Bilimdeki düşünceler bazen değişir”
3. “Bilim insanları, bilimde neyin doğru olduğu ile ilgili düşüncelerini bazen değiştirirler”

Nesnel olmayış
1. “Bilim insanları bilim hakkında hemen hemen her şeyi bilir, yani bilinecek daha fazla bir şey kalmamıştır”
2. “Bilim insanının bir deneyden aldığı sonuç, o deneyin tek yanıtıdır”
3. “Bilim insanları bilimde neyin doğru olduğu konusunda her zaman aynı fikirdedirler”

Teori yüklülük/kültürel etki
1. “Bilim insanlarının araştırma faaliyetleri, benimsedikleri teorilerden etkilenir”
2. “Bilim insanları, doğayı incelerken, benimsedikleri teoriler doğrultusunda etkili yöntemleri seçerler”
3. “Farklı kültürlerdeki bilim insanları, doğadaki olayları yorumlarken farklı bilimsel yöntemleri kullanabilir”
4. “Farklı teorileri benimseyen bilim insanları, aynı doğa olayı hakkında tamamen farklı gözlemler yapabilir”
5. “Bilimsel bilginin gelişimi farklı kültürlerde farklılık gösterebilir”
6. “Bilim insanlarının benimsedikleri teoriler yeni bilimsel gelişmeleri etkiler”
7. “Bilim insanlarının gözlemleri benimsedikleri teorilerden etkilenir”
8. “Bilim insanlarının benimsediği teoriler, onların bilimsel araştırma sürecini etkiler”