International Journal of Education & Literacy Studies
ISSN: 2202-9478
www.ijels.aiac.org.au

High School Students' and Parents' Perceptions of the Nature of Science

Süleyman Akçay[1]*, Gülderen Sultan Türkmen[2]

[1]*Department of Mathematics and Science Education, Süleyman Demirel University, Türkiye*

[2]*Science Education Programme, Institute of Educational Sciences, Süleyman Demirel University, Türkiye*

Corresponding author: Süleyman Akçay, E-mail: suleyman.akcay@gmail.com

ARTICLE INFO

Article history
Received: July 09, 2023
Accepted: September 22,2023
Published: October 31, 2023
Volume: 11 Issue: 4

Conflicts of interest: None
Funding: None

Note: This article was produced from the second author's master's thesis under the supervision of the first author.

ABSTRACT

Today, only people, who truly understand what scientific knowledge is and how it is obtained, are considered scientifically literate. This understanding expected in today's scientific areas is called the nature of science (NOS). This study aimed to determine the perceptions of high school students and their parents regarding NOS. In addition, the changes in high school students' and their parents' perceptions of NOS according to various variables were examined. The data of the research were collected in the second semester of the 2021-2022 academic year. The research involves students and their parents studying in high schools in Konya, a Central Anatolian province of Turkey. The sample group of the research consists of 428 high school students and 428 of their parents. "NOS Questionnaire as Argumentation (NSAAQ)" developed by Sampson and Clark (2006) and translated into Turkish by Çetin et al. (2010) was used. As the results showed, students' perceptions of NOS did not differ significantly according to gender, grade level, place of residence, and average monthly income of the family. Only in the first dimension (How do you define scientific knowledge?) was there a significant difference between parents in favor of men. However, this difference had a low effect size. On the other hand, the fact that parents with higher education had average score and the existence of a significant linear correlation between NOS perceptions of students and their parents were two noteworthy findings. From this perspective, it can be said that today's formal education process in Turkey has significant deficiencies in terms of a more advanced understanding of NOS. In summary, it is clear that the desired development has not been achieved in the perceptions of high school students regarding NOS in formal education in Turkey.

Key words: Nature of Science (NOS), High School Students, Students' Perceptions, Parents' Perceptions

INTRODUCTION

The speed of scientific discoveries and the transformation of knowledge highlight the need for individuals who have realized creative learning in the world (Uğurlu, 2019). In this sense, having the ability to produce scientific knowledge has passed into the literature as scientific literacy. Scientific literacy has been one of the main focuses in the curricula of today's developed countries. In scientific literacy, the nature of science (NOS) is the most basic component (Holbrook and Rannikmae, 2007; Holbrook and Rannikmae, 2009; Roberts and Bybee, 2014). Scientific literacy basically includes the ability to distinguish between scientific and non-scientific. It is known that societies consisting of people with advanced scientific literacy have healthier reasoning skills on issues related to science (Tamer, 2021).

Events such as the First World War and the Second World War affected the need for necessary and practical knowledge for daily life and therefore science education. At the end of this process, science teaching curricula of developed countries, especially the USA, focused on scientific reasoning skills. In addition, the concept of scientific literacy gained strength in science education curricula for this purpose (Lederman and Lederman, 2012; Lederman et al., 2013; McComas and Nouri, 2016). In Turkey, similarly, there is a special purpose in the current science curricula as "To help scientists understand how scientific knowledge is created, the processes through which this knowledge is created, and how it is used in new research" (MEB, 2018).

In studies conducted with students at different levels in different countries, it has been stated that most of the students have inexperienced views about the nature of scientific research (Cofré et al., 2019; Höttecke and Allchin, 2020). It is also known that the development of understandings about NOS is a very challenging and multifaceted process (Clough, 2018).

Important clues have been obtained that individuals who better understand NOS can be sought from political and

Published by Australian International Academic Centre PTY.LTD.

http://dx.doi.org/10.7575/aiac.ijels.v.11n.4p.353

belief-based stereotypes in society (Weisberg et al., 2021). Again, a good understanding of NOS makes science one of the unifying fundamental elements of society and culture (Driver et al., 1996). In this regard, one of the most important goals of science education is to teach not only the content of science but also NOS (Kaya et al., 2019).

In many countries, NOS has been included as the basic component of scientific literacy in curriculums that provide the theoretical framework of teaching in classrooms (McComas, 2014; McComas and Olson, 1998; MoNE, 2018). However, there are deficiencies in many components of NOS in other pillars of teaching practice in classrooms (e.g. textbooks) (Abd-El-Khalick et al., 2008; Atakan and Akçay, in press; DiGiuseppe, 2014; McDonald and Abd-El-Khalick, 2017; Aydin and Tortumlu, 2015). During the quarantine period brought about by the Covid-19 epidemic, people had more contact with the media than in the past. News was conveyed to people through media such as the Internet, television, radio, newspapers and periodicals. However, the necessity of people's ability to scientifically filter the news flows they are exposed to has never been felt so deeply (Bergman, 2022; Demirdöğen, Aydın-Günbatar, 2021).

It is obvious that being personally involved in scientific research is the most effective method in terms of improving students' NOS acquisitions. However, this is almost impossible to achieve in formal teaching processes. Nevertheless, it is more likely to overcome this difficulty by getting support from various teaching methods (Abd-El-Khalick and Lederman, 2000; Akerson and Carter, 2022). Centering the basic components of NOS in the classrooms at all levels and in the preparation of all teaching materials seems to be the most efficient teaching way for students to acquire NOS acquisitions (Bugingo et al., in press; Soudani, in press). Individuals who have a good grasp of NOS are considered scientifically literate. In addition, these individuals can reach healthier conclusions on socioscientific issues. In summary, the main condition for being a productive society is scientific literacy and therefore an improved perception of NOS (DeBoer, 2000; Dienes, 2023; Herman et al., 2019; Vilanova and Martins, 2020).

Objective and Research Questions

In line with the points mentioned above, it is important to determine high school students' perceptions of NOS, because high school is the last step of compulsory education before university in Turkey. Determining NOS understandings at this level provides a snapshot of previous teaching processes in terms of NOS. Only in this way can we see our shortcomings and develop appropriate solutions (Alisir and Irez, 2020; Eymur, 2019).

The concept of NOS is explicitly included in the primary school science curriculum in Turkey for the first time in 2004 (Aliyazıcıoğlu, 2012). In this context, an important objective is to investigate the effect of this theoretical change on the next formal education process. Only by finding an inclusive and realistic answer to this question can we design new teaching processes in the field of NOS. The main problem of this research is to investigate the level of high school student's perception of NOS and its relationship with some variables. Specifically, answers were sought to the following research questions:

1. What are high school students' perceptions of NOS in terms of
   a. The way in which scientific knowledge is defined?
   b. The way in which scientific knowledge is produced?
   c. The way in which reliable and valid scientific knowledge is defined?
   d. The role of scientists in producing scientific knowledge?
2. Do the levels of students' perceptions of NOS differ by gender, grade level, place of residence they live in and average monthly income of their families?
3. What are parents' perceptions of NOS in terms of
   a. The way in which scientific knowledge is defined?
   b. The way in which scientific knowledge is produced?
   c. The way in which reliable and valid scientific knowledge is defined?
   d. The role of scientists in producing scientific knowledge?
4. Do the levels of parents' perceptions of NOS differ by gender, education level and weekly working hours?
5. What is the relationship between high school students' and their parents' perceptions of NOS?

METHODOLOGY

Research Design

This research was carried out using the survey model, one of the quantitative research methods, in order to determine the perceptions of high school students and their parents about NOS. In this model, quantitative data is collected from very large samples. Studies carried out with the survey model offer an important vision for future research in the literature (Büyüköztürk et al., 2011).

Participants

Uninterrupted compulsory education in Turkey has been increased to 12 years with the 4+4+4 model since the 2012-2013 academic year. With this practice, the first level of primary education has been reduced from 5 to 4 years, the second level of primary education (secondary school) has been increased from 3 to 4 years, and the high school education period has been determined as 4 years (Coşkun, 2020). The students forming the sample of this study were made up of high school students.

Sampling Method

The population of the research consists of high school students and their parents living in Konya city Centre. According to the data of the Ministry of National Education, about 50 thousand students completed secondary education at the end of 2022 within the borders of Konya province (MoNE, 2022). The research was carried out on a sample

Table 1. Distribution of participants by demographic variables

Group	Variable	Category	*f*	%
Students	Gender	Woman	273	63.8
		Male	155	36.2
		Total	428	100
	Grade	9th grade	109	25.5
		10th Grade	103	24.1
		11th grade	100	23.4
		12th Grade	116	27.1
		Total	428	100
	Residential aria	Province	107	20
		County	206	48.1
		Village	97	22.7
		Town	18	4.2
		Total	428	100
	Family's monthly income	Low	70	16.4
		Middle	99	23.1
		High	259	60.5
		Total	428	100
Parents	Gender	Woman	242	56.5
		Male	186	43.5
		Total	428	100
	Level of education	Primary education	180	42.1
		Middle education	188	43.9
		High education	60	14
		Total	428	100
	Weekly working hours	Working (1-39 hours per week)	101	23.6
		Working (40 hours or more per week)	127	29.7
		Not working	184	43.0
		Retired	16	3.7
		Total	428	100

Table 2. Findings on the scores of high school students from NOS questionnaire

Dimension	N	*M*
Definition of scientific knowledge	428	3.17
Production of scientific knowledge	428	3.14
Production of reliable and valid scientific knowledge	428	3.16
Role of scientists in producing scientific knowledge	428	3.15

selected from this universe by the convenience sampling method. Using this method, the researcher starts to create his sample starting from the most accessible respondents to reach the study group he needs for research, or works on a situation and example that will be the most accessible and provide maximum savings (Büyüköztürk et al., 2011). This research was carried out with a sample selected from the universe created by these students. It was considered sufficient to reach at least 381-593 students with a tolerance of at least 5% for the representation of the universe (Cohen et al., 2007, p. 104). As a result, 856 responds were collected from 428 high school students and their parents.

Data Collection Tool and Process

In this study, the "NOS as Argument Questionnaire (NSAAQ)" developed by Sampson and Clark (2006) was used to determine the perceptions of high school students and their parents about NOS. The questionnaire was translated into Turkish by Çetin et al. (2010). It consists of 4 dimensions with 26 items. Each item presents two argument named A and B. A represents the strong perception of NOS whereas B represent the naïve perception. Respondents are asked two rate each item based on a 5-point Likert type scale where 1 = strongly agree with A argument, 5= strongly agree with B argument. Those items with negative meaning are reversely scored. A composite variable is constructed by calculating average of all item scores.

The NSAAQ consists of 4 dimensions. The first one asks "How do you define scientific knowledge?" It investigates whether there is an acceptable and strong perception with the question. This dimension consists of 6 items numbered 2-3-5 and 1-4-6. The second dimension seeks an answer to the question "How is scientific knowledge produced?" and investigates whether there is a strong perception on this subject. This dimension consists of 6 items numbered 7-11-12 and 8-9-10. The third dimension asks "How to produce reliable and valid scientific knowledge?" It investigates whether there is an acceptable and strong perception as an answer to the question. This dimension consists of 7 items numbered 13-16-17 and 14-15-18-19. The fourth dimension asks "What is the role of the scientist in the production of scientific knowledge?" and investigates whether there is an acceptable perception as an answer to the question. This dimension consists of 7 items numbered 20-21-24 and 22-23-25-26 (Çetin et al., 2010).

The data collection process of the study was carried out in the 2nd semester of the 2021-2022 academic year. The data were collected remotely due to the difficulty of face-to-face

Table 3. Findings of t-test for students' perceptions of NOS by gender

Dimensions	Gender	*n*	*M*	*SD*	*df*	*t*	*p*
Definition of scientific knowledge	Woman	276	3.22	0.58	426	1.90	0.06
	Male	152	3.09	0.75			
Production of scientific knowledge	Woman	276	3.16	0.59	426	1.04	0.30
	Male	152	3.10	0.64			
Production of reliable and valid scientific knowledge	Woman	276	3.17	0.55	426	0.23	0.82
	Male	152	3.15	0.67			
Role of scientists in producing scientific knowledge	Woman	276	3.17	0.58	426	0.73	0.47
	Male	152	3.12	0.68			

Table 4. Findings of one-way ANOVA test for students' perceptions of NOS according to other variables

Variables	Dimensions	Groups	*M*	*SD*	*F*	*p*
Grade	Definition of scientific knowledge	9th Grade	3.17	0.64	0.47	0.70
		10th Grade	3.21	0.62		
		11th Grade	3.21	0.64		
		12th Grade	3.12	0.68		
	Production of scientific knowledge	9th Grade	3.17	0.65	0.30	0.82
		10th Grade	3.14	0.60		
		11th Grade	3.16	0.63		
		12th Grade	3.10	0.57		
	Production of reliable and valid scientific knowledge	9th Grade	3.23	0.58	1.14	0.33
		10th Grade	3.19	0.57		
		11th Grade	3.10	0.62		
		12th Grade	3.12	0.59		
	Role of scientists in producing scientific knowledge	9th Grade	3.25	0.58	2.45	0.06
		10th Grade	3.19	0.61		
		11th Grade	3.16	0.60		
		12th Grade	3.03	0.64		
Residential aria	Definition of scientific knowledge	Province	3.17	0.69	1.38	0.25
		County	3.23	0.60		
		Village	3.22	0.46		
		Town	3.05	0.72		
	Production of scientific knowledge	Province	3.18	0.68	0.60	0.61
		County	3.13	0.56		
		Village	3.25	0.58		
		Town	3.10	0.65		
	Production of reliable and valid scientific knowledge	Province	3.15	0.66	0.84	0.47
		County	3.21	0.56		
		Village	3.14	0.47		
		Town	3.08	0.61		
	Role of scientists in producing scientific knowledge	Province	3.13	0.69	1.42	0.24
		County	3.15	0.55		
		Village	3.15	0.64		
		Town	3.18	0.65		
Family's monthly income	Definition of scientific knowledge	Low	3.27	0.60	1.80	0.17
		Middle	3.08	0.65		
		High	3.18	0.66		
	Production of scientific knowledge	Low	3.25	0.59	0.10	0.91
		Middle	2.96	0.54		
		High	3.17	0.62		
	Production of reliable and valid scientific knowledge	Low	3.23	0.28	0.79	0.45
		Middle	3.08	0.63		
		High	3.17	0.60		
	Role of scientists in producing scientific knowledge	Low	3.22	0.63	0.37	0.69
		Middle	3.16	0.63		
		High	3.14	0.61		

data collection caused by the Covid-19 pandemic. The NSAAQ was transferred to digital media via Google forms. In addition, a 45-minute meeting was held with 2 graduate students, including the researchers. In this meeting the independent variables (demographic variables) to be asked before the scale were determined.

Data Analysis

For the analysis of the data, it was first examined whether the data, which is the basic assumption of parametric tests, are normally distributed or not. For this, skewness coefficients were used. If any of the skewness values are within the -2/+2, these data are considered to have a normal distribution (George and Mallery, 2019). While examining the differences between the groups, parametric tests were used as all the dependent variables showed normal distribution. These are independent sample t-test and one-way ANOVA tests. In case of significant difference in the ANOVA test, a pairwise comparison was made by applying the Scheffe test. Pearson correlation coefficients was calculated because the data showed normal distribution while examining the relationship between the variables.

FINDINGS

In this section, the findings obtained from the research are discussed in line with each research questions. The results are presented in the form of tables. Table 1 presents the demographic variables of the participant. Most of the students (63.8%) were female while 36.2% were male students. When the class variable was examined, it was seen that 25.5% were 9th grade, 24.1% were 10th grade, 23.4% were 11th grade and 27.1% were 12th grade. It was seen that 56.5% of the parents were female and 43.5% were male. Regarding education level, it was seen that 42.1% of them were at primary education (1-8th grade), 43.9% at middle education (9-12th grade) and 14% were at high education (university level) (Table 1).

High School Students' Perception of NOS

When Table 2 was examined, it was seen that the average score of the students' NOS perceptions was the highest in the first dimension and the lowest in the second dimension.

Table 5. Findings on the parents' scores from NOS questionnaire

Dimensions	N	*M*
Definition of scientific knowledge	428	3.12
Production of scientific knowledge	428	3.14
Production of reliable and valid scientific knowledge	428	3.07
Role of scientists in producing scientific knowledge	428	3.14

Comparing High School Students 'Perception of NOS across Some Variables

According to the findings in Table 3, it was seen that there was no significant difference between NOS perceptions of the students according to their gender.

In accordance with the findings in Table 4, it was seen that NOS perceptions of the students did not show a significant change according to their grade, residential area, and monthly income of the family.

Parents' Perceptions of NOS

According to the data in Table 5, it was seen that the lowest average is in the third dimension (Production of reliable and valid scientific knowledge) (Mean=3.07). Highest averages were in the second dimension (Mean=3.14) (Production of scientific knowledge) and fourth dimension (Role of scientists in producing scientific knowledge).

Comparing Parents' Perception of NOS across Some Variables

The difference in parents' perceptions of NOS according to gender was investigated with the t-test. There was a significant difference in parents' perceptions of NOS according to their gender only in the first dimension (how would you define scientific knowledge?) (p>.05). This difference is a significant difference in favor of men (Table 6).

According to the results in Table 7, the perceptions of the parents on NOS did not show a significant difference according to their education level and weekly working hours.

The Relationship Between Parents' And Students' Perceptions of NOS

The findings in Table 8 show very strong relationships between student and parent perceptions. Correlation analysis is a process that helps determine the relationship between two variables. As the correlation coefficient gets closer to -1, it shows a strong negative relationship. Correlation coefficient values approaching +1, on the other hand, describe a strong positive relationship (Can, 2020). The finding of a

Table 6. Findings of t-test for parents' perceptions of NOS by gender

Dimensions	Gender	*n*	*M*	*SD*	*df*	*t*	*p*	*η2*
Definition of scientific knowledge	Woman	239	3.07	0.60	426	-2.11	0.04*	0.01
	Male	189	3.20	0.70				
Production of scientific knowledge	Woman	239	3.13	0.59	426	-0.55	0.58	0.00
	Male	189	3.16	0.63				
Production of reliable and valid scientific knowledge	Woman	239	3.07	0.62	426	-0.22	0.82	0.00
	Male	189	3.09	0.63				
Role of scientists in producing scientific knowledge	Woman	239	3.15	0.64	426	0.36	0.72	0.00
	Male	189	3.13	0.67				

*$P < 0.05$

Table 7. Findings of one-way ANOVA test for parents' perceptions of NOS according to other variables

Variables	Dimensions	Groups	*M*	*SD*	*F*	*p*
Level of education	Definition of scientific knowledge	Primary education	3.13	0.67	0.22	0.80
		Middle education	3.14	0.61		
		High education	3.08	0.70		
	Production of scientific knowledge	Primary education	3.15	0.62	0.48	0.62
		Middle education	3.12	0.62		
		High education	3.21	0.55		
	Production of reliable and valid scientific knowledge	Primary education	3.09	0.66	0.20	0.98
		Middle education	3.08	0.61		
		High education	3.08	0.58		
	Role of scientists in producing scientific knowledge	Primary education	3.15	0.72	0.58	0.94
		Middle education	3.13	0.62		
		High education	3.14	0.55		
Weekly working hours	Definition of scientific knowledge	Working (1-39 hours per week)	3.17	0.77	0.25	0.86
		Working (40 hours or more per week)	3.13	0.64		
		Not working	3.11	0.60		
		Retired	3.07	0.52		
	Production of scientific knowledge	Working (1-39 hours per week)	3.11	0.65	0.24	0.87
		Working (40 hours or more per week)	3.16	0.63		
		Not working	3.16	0.58		
		Retired	3.07	0.60		
	Production of reliable and valid scientific knowledge	Working (1-39 hours per week)	3.05	0.73	0.98	0.40
		Working (40 hours or more per week)	3.12	0.55		
		Not working	3.08	0.61		
		Retired	2.87	0.75		
	Role of scientists in producing scientific knowledge	Working (1-39 hours per week)	3.10	0.70	0.79	0.50
		Working (40 hours or more per week)	3.16	0.59		
		Not working	3.17	0.65		
		Retired	2.93	0.91		

Table 8. Correlation analysis of high school students and their parents' perceptions of NOS

Correlation type	Variables		Students' perception of NOS	Parents' perception of NOS
Pearson	Students' perception of NOS	Correlation coefficient	1	0.70**
		p (2-way)		0.000
		n	428	428
	Parents' perception of NOS	Correlation coefficient	0.70**	1
		p (2-way)	0.000	
		n	428	428

** Correlation is significant at the 0.01 level (2-tailed).

correlation coefficient of 0.70 between students and their parents' perceptions of NOS indicated that there was a significant strong positive relationship. From this point of view, it can be said that the students' perceptions of NOS explain 49% at the variance in parents' perceptions of NOS (r^2=0.49) (Büyüköztürk, 2011).

DISCUSSION

The maximum average score that can be obtained from the five-point Likert-type scale is 5. In this sense, it can be said that the participants' perceptions of NOS are at a moderate level. Similar to the findings in this study, Demir and Akarsu (2018) also found that secondary school students did not have strong perceptions of NOS. In addition, Eyceyurt Türk and Tüzün (2017) reported that Turkish high school students had various myths about NOS.

No significant differences were found among students' perceptions of NOS according to gender, class level, place of residence, and income status of their families. In terms of parents, a significant difference was determined in favor of males in the first dimension (definition of scientific knowledge). However, when the effect size of this difference is considered, it is seen that it has a fairly small effect value (Table 6).

Perhaps the first of the two most important findings of this study is that parents' perceptions of NOS do not differ significantly according to their education level although parents with higher education received at least an average of 12 or more years of formal education compared to those with primary education (Coşkun, 2020). As a result, they are expected to have a more advanced perception of NOS. The second is the finding of a significant relationship between students' and their parents' perceptions of NOS. Almost half (49%) of students' perceptions about NOS are due to their parents' perceptions about NOS. This is a significant finding for students who are in the last step of their compulsory formal education process. Based on this finding, it would not be wrong to say that students in the last step of the compulsory formal education process did not gain the desired perception of NOS within the education processes.

CONCLUSION

According to Aydemir et al. (2016), science teachers' and pre-service science teachers' perceptions of NOS were found to be insufficient in raising scientifically literate individuals. In this sense, it seems inevitable to emphasize the discipline of NOS, especially in teacher training processes. There are many studies in the international literature showing that teaching history of science is effective in helping students develop a more advanced understanding of NOS (e.g. Brown, 1991; Kim and Irving, 2010; Rudge et al., 2014; Wolfensberger and Canella, 2015). In this context, an education that focuses on the history of science from kindergarten is likely to contribute to the development of the perception of NOS.

In the related literature, it is stated that the achievements related to NOS in Turkey are limited in textbooks (Esmer, 2011; Özer et al., 2017). On the other hand, in the revisions made since 2005 in the science curriculum, the elements of the history of science and NOS have been brought to the fore (Özcan and Koştur, 2019). In this context, it would be beneficial for textbook authors to focus primarily on a sophisticated perception of NOS, away from myths. In addition, it has been determined that the media has an important effect on creating a scientist image among students (Steinke et al., 2007). In this sense, it would be beneficial to increase the publications on science in the media for a more sophisticated perception of NOS.

Kaya and Erduran (2016) examined the Turkish science curriculum comparatively with the US and Irish curricula within the framework of NOS. As a result, they viewed the Turkish curriculum was quite weak in terms of socio-scientific issues, collaboration of scientists, peer review in science, and financing of science.

On the other hand, it is argued that a holistic and nature-of-science-oriented approach is necessary in all processes of education in order to properly acquire NOS achievements (McComas et al., 2020; Nouri et al., 2021). In fact, it has been argued that starting education focused on NOS achievements at an early age is necessary and critical for a more meaningful and effective scientific literacy (Hansson et al., 2021). In this context, it can be said that radical reforms are necessary at every stage of education in Turkey, especially in the science curricula.

It is known that teachers, who are the critical and fundamental pillar of education, must be trained in order to be qualified in NOS (Kite et al., 2021). However, it was found that teachers trained in NOS had significant deficiencies in their subsequent classroom practices and were reluctant to reflect the training they have received into the classroom (Herman et al., 2013). In this sense, providing ready-made thematic activities, especially those focused on the history of science that teachers can easily use in classrooms will be useful in breaking this reluctance.

In addition, it may be useful to produce fictional and story-type reading books on the history of science for every level of education. The Ministry of National Education is expected to undertake the driving role here.

REFERENCES

Abd-El-Khalick, F., & Lederman, N. G. (2000). Improving Science Teachers' Conceptions of Nature of Science: Acritical Review of the Literature. *International Journal of Science Education*, 22, 665–701.

Abd-El-Khalick, F., Waters, M., & Le, A. P. (2008). Representations of Nature of science in High School Chemistry Textbooks over the Past Four Decades. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, 45(7), 835-855.

Akerson, V. L., & Carter, I. S. (Eds.). (2022). *Teaching* Nature of science *Across Contexts and Grade Levels: Explorations through Action Research and Self-Study*. Monument, Colorado: ISTES Organization.

Alisir, Z. N., & Irez, S. (2020). The Effect of Replicating Historical Scientific Apparatus on High School Students' Attitudes towards Science and Their Understanding of Nature of Science. *Science & Education*, *29*(5), 1201-1234.

Aliyazıcıoğlu, S. (2012). *Bilimin Doğası Öğretiminde Bütüncül Bir Yaklaşım: Farklı Branşlardan Öğretmenlerin Bilimin Doğası Algıları* [Unpublished doctoral dissertation]. Marmara Üniversitesi, İstanbul, Türkiye.

Atakan, M., & Akçay, B. (in press). Representation of Changes about Nature of Science in Turkish Middle School Science Textbooks. *Science & Education*, 1-30. https://doi.org/10.1007/s11191-022-00403-6

Aydemir, S., Kazanç, S., & Cırıt, D. K. (2016). Fen Bilgisi Öğretmen ve Öğretmen Adaylarının Bilimin Doğasına İlişkin Görüşlerinin Araştırılması. *Turkish Journal of Educational Studies, 3*(3), 42-70.

Aydin, S., & Tortumlu, S. (2015). The Analysis of the Changes in Integration of Nature of Science into Turkish High School Chemistry Textbooks: Is There Any Development? *Chemistry Education Research and Practice*, *16*(4), 786-796.

Bergman, D. J. (2022). Teaching the Nature of science in A Post-Covid World. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *95*(2), 64-68.

Brown, R. A. (1991). Humanizing Physics Through Its History. *School Science and Mathematics, 91*(8), 357-361

Bugingo, J. B., Yadav, L. L., Mugisha, I. S., & Mashood, K. K. (in press). Improving teachers' and Students' Views on Nature of Science Through Active Instructional Approaches: A Review of the Literature. *Science & Education*, 1-43. https://doi.org/10.1007/s11191-022-00382-8

Büyüköztürk, Ş. (2011). *Sosyal Bilimler İçin Veri Analizi El Kitabı. Pegem Akademi*.

Büyüköztürk, Ş., Kılıç Çakmak, E., Akgün, Ö. E., Karadeniz, Ş., & Demirel, F. (2011). *Scientific Research Methods*. Pegem Akademi.

Can, A. (2020). *SPSS İle Bilimsel Araştırma Sürecinde Nicel Veri Analizi*. Pegem Akademi.

Çetin, P. S., Erduran, S., & Kaya. (2010). Kimyanın Doğası ve Argümantasyonu Anlama: Kimya Öğretmen Adayları İle Bir Durum Çalışması. *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi*, *11*(4), 41-59.

Clough, M. P. (2018). Teaching and Learning about the Nature of Science. *Science & Education*, *27*, 1-5.

Cofré, H., Núñez, P., Santibáñez, D., Pavez, J. M., Valencia, M., & Vergara, C. (2019). A Critical Review of Students' and Teachers' Understandings of Nature of Science. *Science & Education*, *28*, 205-248.

Cohen, L., Manion, D., & Morrison, K. (2007). *Research Methods in Education* (6th ed.). Rutledge.

Coşkun, M. (2020). A Comparative Study of Nations' Compulsory Education Process and Pisa Achievements. *International Journal of Leadership Studies: Theory and Practice, 3*(3), 124-137.

DeBoer, G. E. (2000). Scientific Literacy: Another Look at Its Historical and Contemporary Meanings and Its Relationship to Science Education Reform. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *37*(6), 582-601.

Demir, N., & Akarsu, B. (2018). Secondary School Students' Perceptions about the Nature of Science. *Journal of European Education*, *3*(1), 32-41.

Demirdöğen, B., & Aydın-Günbatar, S. (2021). Teaching Nature of Science Through the Use of Media Reports on COVID-19. *Science Activities*, *58*(3), 98-115.

Dienes, Z. (2023). The Credibility Crisis and Democratic Governance: How to Reform University Governance to Be Compatible with The Nature of Science. *Royal Society Open Science*, *10*(1), 220808.

DiGiuseppe, M. (2014). Representing Nature of science in A Science Textbook: Exploring Author–Editor–Publisher Interactions. *International Journal of Science Education*, *36*(7), 1061-1082.

Driver, R., Leach, J., Miller, R., & Scott, P. (1996). *Young People's Images of Science*. Buckingham: Open University Press.

Esmer, F. (2011). *Exploring Representation of* Nature of science *Aspects in 9th Grade Chemistry Textbooks* [Unpublished master dissertation]. Middle East Technical University, Türkiye.

Eyceyurt Türk, G., & Tüzün, Ü. N. (2017). High School Students' Scientist Images and Their Nature of Science Myths. *Ahi Evran University Journal of Kırşehir Education Faculty, 18*(2), 19-36

Eymur, G. (2019). The Influence of the Explicit Nature of Science Instruction Embedded in The Argument-Driven Inquiry Method in Chemistry Laboratories on High School Students' Conceptions about the Nature of Science. *Chemistry Education Research and Practice*, *20*(1), 17-29.

George, D., & Mallery, P. (2019). *IBM SPSS Statistics 26 Step by Step: A Simple Guide and Reference*. Routledge.

Hansson, L., Leden, L., & Thulin, S. (2021). Nature of Science in Early Years Science Teaching. *European Early Childhood Education Research Journal*, *29*(5), 795-807.

Herman, B. C., Clough, M. P., & Olson, J. K. (2013). Teachers' Nature of Science Implementation Practices 2–5 Years after Having Completed an Intensive Science Education Program. *Science Education*, *97*(2), 271-309.

Herman, B. C., Owens, D. C., Oertli, R. T., Zangori, L. A., & Newton, M. H. (2019). Exploring The Complexity of Students' Scientific Explanations and Associated Nature of Science Views Within a Place-Based Socioscientific Issue Context. *Science & Education*, *28*, 329-366.

Holbrook, J., & Rannikmae, M. (2007). The Nature of science Education for Enhancing Scientific Literacy. *International Journal of Science Education*, *29*(11), 1347-1362.

Holbrook, J., & Rannikmae, M. (2009). The Meaning of Scientific Literacy. *International Journal of Environmental and Science Education*, *4*(3), 275-288.

Höttecke, D., & Allchin, D. (2020). Reconceptualizing Nature-of-Science Education in the Age of Social Media. *Science Education*, *104*(4), 641-666.

Kaya, E., & Erduran, S. (2016). From FRA to RFN, or How the Family Resemblance Approach can be Transformed for Science Curriculum Analysis on Nature of Science. *Science & Education*, *25*, 1115-1133.

Kaya, E., Erduran, S., Aksoz, B., & Akgun, S. (2019). Reconceptualised Family Resemblance Approach to Nature of Science in Pre-service Science Teacher Education. *International Journal of Science Education*, *41*(1), 21-47.

Kim, S. Y., & Irving, K. E. (2010). History of Science as an Instructional Context: Student Learning in Genetics and Nature of Science. *Science & Education, 19*, 187–215. http://doi.org/10.1007/s11191-009-9191-9

Kite, V., Park, S., McCance, K., & Seung, E. (2021). Secondary Science Teachers' Understandings of the Epistemic Nature of Science Practices. *Journal of Science Teacher Education*, *32*(3), 243-264.

Lederman, N. G., & Lederman, J. S. (2012). Nature of Scientific Knowledge and Scientific Inquiry: Building Instructional Capacity through Professional Development. In B. J., Fraser, K. G., Tobin, & C. J., McRobbie (Eds.), *Second International Handbook of Science Education* (pp. 335-359). Springer.

Lederman, N. G., Lederman, J. S., & Antink, A. (2013). Nature of Science and Scientific Inquiry as Contexts for the Learning of Science and Achievement of Scientific Literacy. *International Journal of Education in Mathematics, Science and Technology*, 1(3), 138-147.

McComas, W. F. (2014). Nature of science in the Science Curriculum and in Teacher Education Pro-grams in the United States. In M. R. Matthews (Ed.), *International Handbook of Research in History, Philosophy and Science Teaching* (pp. 1993–2023). Springer.

McComas, W. F., & Nouri, N. (2016). The Nature of Science and the Next Generation Science Standards: Analysis and Critique. *Journal of Science Teacher Education, 27*(5), 555-576.

McComas, W. F., & Olson, J. K. (1998). The Nature of Science in International Science Education Standards Documents. In W. F. McComas (Ed.), *The Nature of science in Science Education: Rationales and Strategies* (pp. 41–52). Kluwer.

McComas, W. F., Clough, M. P., & Nouri, N. (2020). Nature of Science and Classroom Practice: A Review of the Literature with Implications for Effective NOS Instruction. In W. F. McComas (Eds.), *Nature of Science in Science Instruction: Rationales And Strategies* (pp. 67-111). Springer.

McDonald, C. V., & Abd-El-Khalick, F. (Eds.). (2017). *Representations of* Nature of Science *in School Science Textbooks: A Global Perspective*. Routledge.

MoNE (Ministry of National Education). (2018). *Science Course (3, 4, 5, 6, 7 and 8. Classes) Curriculum,* National Education Printing House.

MoNE (Ministry of National Education). (2022). *National Education Statistics: Formal Education 2021-2022*. National Education Printing House.

Nouri, N., Saberi, M., McComas, W. F., & Mohammadi, M. (2021). Proposed Teacher Competencies to Support Effective Nature of Science Instruction: A Meta-synthesis of the Literature. *Journal of Science Teacher Education*, *32*(6), 601-624.

Özcan, H., & Koştur, H. İ. (2019). The Investigations of Science Curriculum Acquisitions in Terms of Special Purposes and Field-Specific Skills. *Trakya Journal of Education*, *9*(1), 138-151.

Özer, F., Doğan, N., Çakmakçı, G., İrez, S., & Yalaki, Y. (2017). A Contextualized Nature of Science Classroom Activity: Junk Food. *Journal of Inquiry Based Activities, 7*(2), 93-107.

Roberts, D. A., & Bybee, R. W. (2014). Scientific literacy, Science literacy, and Science Education. In *Handbook of Research on Science Education, Volume II* (pp. 559-572). Routledge.

Rudge, D. W., Cassidy, D. P., Fulford, J. M., & Howe, E. M. (2014). Changes Observed in Views of Nature of Science During a Historically Based Unit. *Science & Education, 23*, 1879–1909. http://doi.org/10.1007/s11191-012-9572-3

Sampson, V., & Clark, D. (2006, April). The Development and Validation of the Nature of Science as Argument Questionnaire (NSAAQ). *In Annual Conference of the National Association for Research in Science Teaching*, San Francisco, CA.

Soudani, M. (in press). Epistemological and Didactic Reflections on Teacher Training in France: Promoting Nature of Science with Children's Literature. *Science & Education*, 1-24. https://doi.org/10.1007/s11191-023-00420-z

Steinke, J., Lapinski, M. K., Crocker, N., Zietsman-Thomas, A., Williams, Y., Evergreen, S. H., & Kuchibhotla, S. (2007). Assessing Media Influences on Middle School–aged Children's Perceptions of Women in Science Using the Draw-A-Scientist Test (DAST). *Science Communication, 29*(1), 35-64.

Tamer, C. (2021). *Argümantasyon Yöntemi ve Doğrudan-yansıtıcı Yaklaşımın Bilimin Doğası Anlayışına Etkisi: Bir Meta Analiz Çalışması* [Unpublished master's dissertation]. Hacettepe Üniversitesi, Ankara, Türkiye.

Uğurlu, K. S. (2018). *The Effect of Argumentation-based Chemistry Experiment Designs on Pre-service Science Teachers' Understanding of the Nature of Science* [Unpublished master dissertation], Bursa Uludağ University, Bursa, Türkiye.

Vilanova, R., & Martins, I. (2020). A Discursive Analysis of Relationships between Nature of Science and Citizenship Education: The Case of Brazilian Science Textbook Evaluation Policies. In H.A. Yacoubian & L. Hansson (Eds.), *Nature of Science for Social Justice* (pp. 115–135). Springer.

Weisberg, D. S., Landrum, A. R., Hamilton, J., & Weisberg, M. (2021). Knowledge about the Nature of Science Increases Public Acceptance of Science regardless of Identity Factors. *Public Understanding of Science*, *30*(2), 120-138.

Wolfensberger, B., & Canella, C. (2015). Cooperative Learning about Nature of Science with a Case from The History of Science. *International Journal of Environmental & Science Education, 10*(6), 865–889. http://doi.org/10.12973/ijese.2015.281a