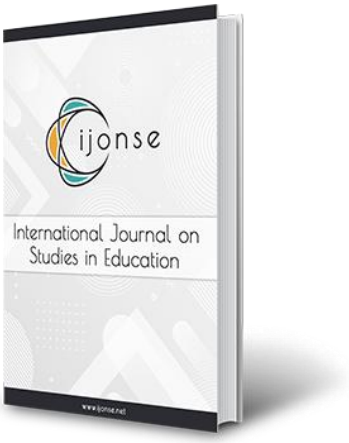

www.ijonse.net

Exploring the Nature of Science Representations in Biology Textbooks

Seyda Gul
Atatürk University, Türkiye

Suat Celik
Atatürk University, Türkiye

To cite this article:

Gul, S. & Celik, S. (2025). Exploring the nature of science representations in biology textbooks. *International Journal on Studies in Education (IJonSE), 7*(3), 563-584. https://doi.org/10.46328/ijonse.1935

International Journal on Studies in Education

2025, Vol. 7, No. 3, 563-584 https://doi.org/10.46328/ijonse.1935

Exploring the Nature of Science Representations in Biology Textbooks

Seyda Gul, Suat Celik

Article Info

Article History

Received:
1 January 2025
Accepted:
7 June 2025

Keywords

Biology education
Nature of science
Reconceptualized family resemblance approach
Textbook

Abstract

The aim of this study is to explore how nature of science is addressed in biology textbooks according to grade level and the chapters. The textbooks examined within the scope of the study are Biology 9 and Biology 10 textbooks. The analysis of the textbooks was based on the Reconceptualized Family Resemblance Approach. The study was conducted through content analysis based on an analytical framework in which aspects of NOS were included. According to the findings, it was determined that there were a total of 246 representations in the Biology 9 textbook about the nature of science. While 165 of these representations are related to the cognitive-epistemic structure of science, 81 are related to the social-institutional aspect. The findings also showed that there were a total of 178 representations related to the NOS in the Biology 10 textbook. While 82 of these representations are related to the cognitive-epistemic structure of science, 96 are related to the social-institutional aspect. No representations about political power structures were found in either textbook. The most frequent representations regarding the cognitive-epistemic structure of science were identified in the dimension of scientific practices in both textbooks. In the social-institutional dimension of science, the most representations were found in the financial aspect science in Biology 9 textbook, and in the scientific ethos sub-dimension in Biology 10 textbook. Chapter 3 in Biology 9 textbook and chapter 3 in Biology 10 textbook are the chapters that contain the most representations to NOS. The results showed that the social-institutional aspect of science is neglected in biology education in accordance with results about other science disciplines in the literature.

Introduction

Changes and developments in science and technology directly affect the education system. In order for science to positively affect society, nature of science (NOS) needs to be understood by individuals (Bell et al., 2011). It is gaining importance to raise scientifically literate individuals who are curious, questioning, researching, aware of the problems around them, and making suggestions for the solution of the problems (Erdemir & Özgür, 2023; Kaya & Erduran, 2016; Yeh et al., 2019). As a matter of fact, one of the main purposes of science education in general and biology education in particular is to have scientifically literate individuals (Deboer, 2000; Hazen & Trefil, 2009; Hurd, 1998). NOS is one of the important and fundamental components of scientific literacy (Cofre et al., 2019; Lederman, Lederman & Antink, 2013; Yeh et al., 2019). As a matter of fact, it is understood that

researchers specializing in the field of science education consider scientific literacy in connection with the understanding of NOS (Kavak et al., 2006).

Teaching NOS has long been the focus of attention of science educators and curriculum developers (Erdemir & Özgür, 2023; Lederman, 2007b; Matthews, 2012). Because, only by understanding NOS, students can develop a deep understanding of scientific enterprise, as well as evaluate scientific knowledge and claims from a critical perspective (Leach et al., 1997; Ryder et al., 1999). As a matter of fact, in parallel with the recognition that it is an important educational outcome for students, NOS has begun to be emphasized more in the curricula of many countries around the world (Bybee et al., 1991; McComas & Olson, 1998; Ramnarain, 2023; Yeh et al., 2019). NOS has even become a main theme in reform documents for science education published in many developed countries. Prominent examples of these initiatives include "the next generation science standards" in the USA and the "national curriculum: science programmes" for study in Great Britain (Chen et al., 2024). Turkish science education has also been affected by these international educational reforms and in recent years more emphasis has been placed on NOS in the curriculum. For example, as in other science subjects in Türkiye, the biology curriculum, which was last updated in 2018, is also emphasising understanding about NOS (Ministry of National Education [MoNE], 2018). In all of the physics, chemistry and biology curricula published by the Education and Training Institution in Türkiye in 2018, it is seen that the importance of questioning individuals as well as scientific literacy is emphasized. Scientific inquiry, which is frequently mentioned in the curricula, is seen as an important tool used to achieve the goal of raising scientifically literate individuals (Turan & Dogan, 2022).

Although the necessity of teaching and integrating NOS into the learning process is accepted by everyone, it cannot be said that there is a consensus on what science and NOS mean (Abd-El-Khalick & Lederman, 2000b; Çelik & Karataş, 2022; Lederman, 2007a). Lederman (1992) refers to NOS as "the way of knowing or the values and beliefs in the nature of the development of scientific knowledge." The reason why there is no consensus on NOS is explained by the multifaceted and complex nature of scientific endeavor (Abd-ElKhalick & Lederman 2000). When the literature was examined, it was determined that students and teachers had insufficient understanding of NOS (Cofre et al., 2019; Erduran & Kaya, 2018; Deng et al., 2011; Kaya et al., 2017; Khishfe, 2022). On the other hand, although the practices that demonstrate the necessity of including NOS in educational programs have gained great momentum in recent years, there are still some problems (Turgut, 2007). For example, in the report prepared by the National Assessment for Progress in Education (NAEP), it was claimed that educators were not able to ensure that students adequately understand NOS (Meichtry, 1992). In the research conducted in Türkiye on NOS, it has been determined that students, teacher candidates and teachers cannot reach the targeted level in their understanding of NOS, that they have insufficient understanding and that there are significant teaching deficiencies in this regard (Celik & Bayrakceken, 2006, 2012; Erdemir & Özgür, 2023; Kurt & Kaya, 2023). Additionally, some studies have been conducted by adopting different approaches on how NOS is represented in textbooks and curriculum (Campanile, Lederman, & Kampourakis, 2015; Okan & Kaya, 2023b). It has also been determined that representations to NOS are not included sufficiently in curriculum and textbooks (Abd-El-Khalick et al., 2017; Cheung & Erduran, 2022; Çelik, & Karataş, 2022; Erduran et al., 2019; Kaya & Erduran, 2016; Okan & Kaya, 2023a, 2023b; Özden & Cavlazoğlu, 2015; Sayın, 2021). Some experimental studies on this subject have revealed that many students have serious misconceptions about the concepts of NOS.

It is thought that most of these misconceptions are due to materials and teaching practices that do not adequately reflect NOS (Meichtry, 1992). For example, many direct or indirect misconceptions are found in textbooks about what science is, how scientists work, and how the scientific method works (Abd-El-Khalick et al., 2008; Binns & Bell, 2015; Irez, 2009; Ramnarain & Chanetsa, 2016). Misrepresentations in science textbooks have a serious impact on students' development of inadequate understandings of NOS components, negatively affecting their overall perceptions of science (Akerson et al., 2008; Duruk & Akgün, 2020; McDonald & Abd-El-Khalick, 2017).

Textbooks are one of the basic tools used in presenting the information in the curriculum (Chen et al., 2024, Vojíř & Rusek, 2019). Researchers from the International Mathematics and Science Survey (TIMSS) found that teachers worldwide frequently use textbooks to guide their lessons. Checkley (1997) reported that approximately 50 percent of the weekly instructional time of science teachers in Japan, Germany, and the United States was taken up by textbooks. Sanchez and Valcarcel (1999) found that a large percentage of teachers in Spain (92 percent) viewed textbooks as "the primary reference for teaching units." In a similar study, Chiappetta et al. (2006) found that more than 90 percent of secondary school science teachers referred to textbooks during instruction. In Türkiye, the materials frequently used in learning environments are textbooks (Şahin, 2015).

In all public schools in Türkiye, textbooks are prepared by the Ministry of National Education, and since 2003, ministry-approved textbooks have been distributed free of charge by the state at all levels of education. Starting from the 2024-2025 academic year, it will be mandatory to teach ministry-approved textbooks in private schools. These textbooks that are compulsory in all schools have been prepared based on the curriculum updated in 2018. The Current Biology Course Curriculum has been updated to include more applications such as making innovations and changes in light of the laws, theories, practices and concepts of biology, research and questioning, using information technologies, establishing a relationship between biology and daily life, creating social awareness, etc (Ministry of National Education [MoNE], 2018). In the literature, there are studies on the determination of learning outcomes that guide teachers in teaching NOS and the extent to which science standards documents, which are effective in the preparation of science programs in many countries, include NOS and its dimensions (Kurt & Kaya, 2023; McComas & Olson, 1998; Sardag et al., 2014). The common finding of these studies is that some dimensions of NOS (e.g. subjectivity in science, the role of creativity in science, etc.) are not sufficiently included in the documents examined. At this point, the issue of how the NOS concept included in the curriculum and science standards documents is integrated into the textbooks becomes important.

Aspects of NOS and Research on Integration of NOS in Textbooks

There are many approaches suggested in the literature regarding NOS. These approaches are 'Consensus View' (Abd-El-Khalick & Lederman, 2000a), 'Holistic Science' (Allchin, 2011), 'Characteristics of Science' (Matthews, 2012) and ‘The Nature of Science Based on the Family Resemblance Approach’ proposed by Irzik and Nola (2014). According to the "Family Resemblance Approach to Nature of Science (FRA to NOS)" presented by Irzik and Nola (2014) and consisting of eight categories, science consists of cognitive-epistemic and social-institutional systems. Erduran and Dagher (2014) reconceptualized this approach by adding new categories, developing visuals for the categories, and offering pedagogical practice suggestions suitable for different grade levels. Kaya and

Erduran (2016) used the name "Reconceptualized Family Resemblance Approach to Nature of Science, RFN" to distinguish this latest version of the approach from others. According to Erduran and Dagher (2014a), science can be considered as a cognitive-epistemic and social-institutional system. The cognitive-epistemic system includes cognitive strategies used for the acquisition, interpretation and application of scientific knowledge. The cognitive-epistemic system also includes categories related to the nature of scientific knowledge and epistemic beliefs. The social-institutional system includes categories that affect the production, dissemination and acceptance of scientific knowledge in a particular society. These categories and their definitions, which constitute the analytical framework of this research, are shown in Table 2.

According to Çelik and Karataş (2022), the purpose of this model is to teach NOS in a conceptual and holistic structure. The model also enables teachers and educators, as well as curriculum developers and textbook authors, to highlight NOS components with their associated topics and concepts (Erduran et al., 2019). Therefore, considering that textbooks are an important tool in achieving the goals of the curriculum (Ramnarain & Chanetsa, 2016; Yang et al., 2020), determining the level of representation of NOS in textbooks with this model may be useful in eliminating misrepresentations of NOS in textbooks. Because misrepresentations in textbooks have a serious impact on the development of inadequate understanding of NOS components, negatively affecting students' general perceptions of science (Akerson, Buzzelli & Donnelly, 2008; Duruk & Akgün, 2020; Khine, 2019; McDonald & Abd-El-Khalick, 2017).

As mentioned before, textbooks, as one of the most important teaching materials in science teaching, provide guidance for teaching NOS by teachers in learning environments. The textbooks are also important basic sources for developing teachers' and students' views on NOS (Abd-El-Khalick et al., 2008; Chen et al., 2024). Therefore, the representations of NOS in science textbooks have an important role in guiding the teaching process and students' learning and have been a subject of study that has attracted considerable attention in the relevant literature (Chen et al., 2024; Wei et al., 2013; Brunner & Abd-El-Khalick, 2020; McComas, 2017; McDonald, 2017).

Based on this, studies in the literature on the level of representation of NOS in textbooks have gained momentum in recent years. In particular, after McComas and Olson (1998) expressed their opinion that textbook analyses should be done more frequently in countries other than developed western countries, Türkiye, Greece, Saudi Arabia, Taiwan, China, South Korea, Singapore and South Africa have responded to this call in recent years. It has been noted that focused textbook analysis studies have increased (Duruk & Akgün, 2020). When studies in the context of Türkiye are examined (Aydın & Tortumlu, 2015; Boyacıoğlu, 2021; Çelik & Karataş, 2022; Duruk & Akgün, 2020; Irez, 2009; Küçükoğuz, 2011; Okan & Kaya, 2023; Sayın, 2021; Ünlü Sinnett Jr, 2021), it is clear that textbooks do not adequately reflect NOS (Khine, 2019; McDonald & Abd-El-Khalick, 2017). In addition, it is seen that the textbooks examined were written at different grade levels and mostly for the field of science and chemistry (Aydın & Tortumlu, 2015; Çelik & Karataş, 2022; Duruk & Akgün, 2020; Küçükoğuz, 2011; Okan & Kaya, 2023; Ünlü Sinnett Jr, 2021). When the studies examining biology textbooks were examined, only studies by Irez (2009), Boyacıoğlu (2021) and Sayın (2021) were found.

The biology textbooks examined in Irez (2009)'s study were at the 10th grade level and were published by different

publishers other than MoNE. In addition, since the curriculum was last updated in 2018, the textbooks examined in Irez (2009)'s study are not up to date for the curriculum updated in 2018. Some of the textbooks reviewed by Boyacıoğlu (2021) were published by MoNE and only genetic chapters were examined. In the study conducted by Sayın (2021), 9th, 10th, 11th and 12th grade biology, chemistry and physics textbooks in accordance with the updated 2018 curriculum were examined using Erduran and Dagher's (2014) Reconceptualized Family Resemblance Approach. However, the Biology 9 and Biology 10 textbooks examined in Sayın's (2021) study were published by different publishers. There is no study in the literature examining the Biology 9 and Biology 10 textbooks published by the Ministry of National Education and used compulsorily in schools. Therefore, this study may provide information on how NOS is represented in current Biology 9 and Biology 10 textbooks. In conclusion, the purpose of this study is to examine how NOS is represented in Biology 9 and Biology 10 textbooks according to RFN and how this varies by grade level and chapters in the textbooks.

Research Questions

1. How is NOS represented relative to RFN in 9th and 10th grade biology textbooks?
2. Which aspects of NOS are discussed more in biology textbooks according to chapters?

Method

This qualitative study was based on the document analysis approach. Document analysis is a method used to systematically examine and evaluate printed and electronic materials. In the document analysis method, data is examined and interpreted to reveal meaning, gain understanding and develop empirical knowledge (Bowen, 2009; Corbin & Strauss, 2008). The documents used in the study are two biology textbooks prepared for 9th grade and 10th grade. Content analysis was used to analyse the textbooks. In content analysis, the texts examined are analysed and summarized under various codes, categories and themes (Krippendorff, 2018). According to qualitative analysis approaches, the categorization process is a process in which mental processes take place, takes a long time and needs to be carefully prepared in different times and places (Ültay et al., 2021). Therefore, content analysis needs to be done carefully. Regarding this, Wang (1998) stated that some issues should be met during the content analysis process. According to Wang (1998), for content analysis, researchers should first determine a conceptual framework and analyses should be conducted by more than one researcher. On the other hand, choosing a specific section or chapter in the material to be content analysed (for example, a book) should be avoided. Accordingly, the analysis process was carried out in the study by taking Wang (1998)'s recommendations into consideration. For this purpose, the RFN structure was used as the analysis framework in the content analysis process of the textbooks in the study. During the coding process, all chapters in the textbooks were included in the analysis. To ensure reliability in the analysis, both researchers analysed the textbooks together. The aspects that make up the RFN structure are briefly introduced and sample representations from textbooks related to each aspects are included.

The analysis method for both textbooks was carried out in the form of page-by-page analysis. Texts, paragraphs, tables, etc. were coded as units of analysis in all pages. Images such as photographs, graphics, etc. were excluded

from the analysis. However, as stated by Chen et al. (2024), student exercises (chapter tests) in the textbooks were excluded from the analysis because they aimed to develop students' skills in transferring and applying knowledge and in analyzing and solving problems that NOS almost never included. Coding was done according to the RFN categories in Table 2. During the coding process, the coder performed the analysis by examining which aspects of NOS were addressed in each paragraph. In cases where a text could be counted in more than one RFN category, attention was drawn to the most distinct meaning and emphasis in the written text, and multiple coding for the same text was avoided. Accordingly, the representations in the first four RFN categories were coded as 1.1-1.4 in the cognitive-epistemic system; while the representations in the other seven categories were coded as 2.1-2.7 in the social-institutional system. To ensure coding reliability, the textbooks were analysed page by page by one of the researchers at two-month intervals. A small number of WOS presentations that were coded differently in the two analyses were identified and these presentations were checked and decided by the two researchers together. After the coding process was completed, the frequency values of the codes in each category were calculated and the findings were presented in tables and figures.

Biology Textbooks Under Investigation

In Türkiye, which has a centralized education system, teachers are required to comply with a framework curriculum prepared by the Ministry of National Education. While science is taught as an integrated subject in primary education, physics, chemistry, and biology are taught as separate subjects in the secondary education curriculum in grades 9–12. On the other hand, the most important exam in a student's life in Türkiye is the two-stage university entrance exam (Irez, 2009).

Although some changes have been made recently, traditionally the university entrance exam evaluates students' content knowledge in various subjects such as biology, chemistry, Turkish and mathematics. Students are required to take this two-stage exam to be placed in a university. First, the Basic Proficiency Test (Turkish name TYT) is taken. TYT is a mandatory exam to be placed in a university and represents the first stage. The second stage is the Field Proficiency Test (Turkish name AYT) test, and students who will be placed in universities with 4 years of education are required to take this exam. In short, all students (associate's degree programs and undergraduate programs) can take the TYT exam, while only students who will receive undergraduate education in a specific field are required to take the AYT exam. TYT exam questions are prepared according to the 9th and 10th grade curriculum. The purpose of the test is to measure logical thinking, reasoning, evaluation and thinking-based problem-solving skills. Additionally, the current biology curriculum in Türkiye is based on NOS in the 9th and 10th grades.

As stated before, the textbooks in Türkiye have been prepared based on the curriculum updated in 2018. In all public schools, textbooks are prepared by the MoNE and private companies, and since 2003, ministry-approved textbooks have been distributed free of charge by the state at all levels of education. Starting from the 2024-2025 academic year, it will be mandatory to teach with ministry-approved textbooks in private schools. For this reason, the MoNE approved textbooks, which are mandatory for all students, were selected for the study.

For the reasons stated above, Biology 9 and Biology 10 textbooks were analysed for the study. Since the latest edition of the textbooks is from 2021, previous edition textbooks were not included in the study. Experts from different fields took part in the preparation of the textbooks. According to this, a language expert, a program development expert, an assessment and evaluation expert, a guidance and development expert, a visual design expert and a graphic design expert took part in the preparation of these textbooks. The content of the textbooks is shown in Table 1.

Table 1. The Content of the Biology Textbooks

Textbook	Chapter Title	Number of Learning outcomes	Topic Title	Pages
Biology 9	1. Life Science Biology	3	1.1. Biology and common characteristics of living things	18-19
			1.2. Basic compounds found in the structure of living things	28-73
	2. The Cell	3	2.1. The cell	86-123
	3. World of the Living Things	5	3.1. Diversity and classification of living things	138-145
			3.2. The kingdom of living things and its features	150-190
Biology 10	1. Cell Divisions	5	1.1. Mitosis and asexual reproduction	17-46
			1.2. Meiosis and sexual reproduction	53-69
	2. General Principles of Heredity	2	2.1. Heritage and biodiversity	81-127
	3. Ecosystem Ecology and Current Environmental Problems	10	3.1. Ecosystem ecology	139-163
			3.2. Current environmental problems and human	171-190
			3.3. Natural Resources and biological diversity protection	195-210

As seen in Table 1, while Biology 9 textbook contains three chapters and five topics; Biology 10 textbook contains three chapters and six topics. All units and topics of the textbooks were included in the analysis.

Results

In this part of the study, the content analysis of biology textbooks according to RFN was conducted and the results were presented by examining to what extent NOS was reflected in the textbooks and how it was represented according to chapters. Kaya and Erduran (2016) were taken as reference for the aspects of NOS. Table 2 gives examples of representations from biology textbooks showing coding based on RFN.

Table 2. Examples of Representations from Biology Textbooks Showing Coding Based on RFN

Aspects of NOS	**Description for the aspects and the excerpts from biology textbooks for NOS representations**
1.1. Aims and values	Description: The key cognitive and epistemic objectives of science, such as accuracy and objectivity
	Excerpt: When Galileo discovered the spots on the surface of the Sun, those around his claimed that the images of the spots on the Sun were caused by the spots on the telescope lenses. (Biology 9, chapter 2, p:100)
1.2. Practices	Description: The set of epistemic and cognitive practices that lead to scientific knowledge through social certification
	Excerpt: Watson and Francis Crick proposed the Double Helix Model, which explains the three-dimensional structure of DNA). Biology 9, chapter 1, p:67)
1.3.Methods and methodological rules	Description: The manipulative as well as non-manipulative techniques that underpin scientific investigations
	Excerpt: Mendel chose the pea plant for his studies on genetics. He identified seven different characters in peas. Mendel's choice of peas in his studies gave him advantages in many ways. (Biology 10, chapter 2, p:84)
1.4. Scientific knowledge	Description: Theories, laws, and explanations that underpin the outcomes of the scientific inquiry
	Excerpt: In addition to these studies, Virchow's studies on the growth and proliferation of cells led to the emergence of an important generalization about the cell. This generalization is called Cell Theory. (Biology 9, chapter 2, p:87)
2.1. Professional activities	Description: How scientists engage in professional settings such as attending conferences and doing publication reviews
	Excerpt: Aziz Sancar and his assistant purified the enzyme that initiates transcription-dependent DNA repair, solved its mechanism, and explained the entire mechanism in a single article. (Biology 10, chapter 2, p:112)
2.2. Scientific ethos	Description: The norms that scientists employ in their work as well as in interaction with colleagues
	Excerpt: People take bulbous plants, which are raw materials, and some snake and insect species abroad without permission. It is known that these creatures carried out scientific studies in the countries where they were taken and obtained patents in their own names. (Biology 10, chapter 3, p:206)
2.3. Social certification and dissemination	Description: The social mechanisms through which scientists review, evaluate, and validate scientific knowledge for instance through peer review systems of journals
	Excerpt: The five-world classification system proposed in 1969 quickly

Aspects of NOS	Description for the aspects and the excerpts from biology textbooks for NOS representations
	became widespread and standard, and this classification is still used today with some improvements. (Biology 9, chapter 3, p.141)
2.4. Social values of science	Description: Values such as freedom, respect for the environment, and social utility
	Excerpt: These findings, which are considered a biological leap, are thought to be of vital importance in cancer treatment development studies. (Biology 10, chapter 1, p.32)
2.5. Social organization and interactions	Description: How science is arranged in institutional settings such as universities and research institutes
	Excerpt: In 1902, Walter Stanborough Sutton and Theodor Boveri demonstrated that genes, which Mendel called heredity factors, were located on chromosomes and were carried with them. (Biology 10, chapter 2, p.80)
2.6. Political power structures	Description: The dynamics of power that exist between scientists and within science cultures
	Excerpt: -
2.7. Financial systems	Description: The underlying financial dimensions of science including the funding mechanisms
	Excerpt: He studied biochemistry for a few years in the USA, where he went with a TÜBİTAK scholarship, but returned to his country due to some social adaptation problems and worked as a physician in his hometown, Savur, for a while. (Biology 10, chapter 2, p.112)

Table 3 shows how NOS is represented relative to RFN in biology textbooks. According to the findings, the total number of representations to NOS in both textbooks is 424. While 247 of these representations are related to the cognitive-epistemic structure of NOS, 177 are related to its social-institutional dimension of science. According to these results, it can be said that in both textbooks, more references are made to the cognitive-epistemic dimension of NOS than to its social-institutional dimension.

Table 3. Representation of NOS relative to RFN in Biology Textbooks

Aspects of NOS		Total
1. Cognitive-Epistemic	1.1 Aims and values	35
	1.2. Practices	139
	1.3. Methods and Methodological rules	58
	1.4. Scientific knowledge	15
Total		247
2. Social-Institutional	2.1. Professional activities	17
	2.2. Scientific ethos	34

Aspects of NOS		Total
	2.3. Social certification and dissemination	19
	2.4. Social values of science	38
	2.5. Social organization and interactions	30
	2.6. Political power structures	-
	2.7. Financial systems	39
Total		177
Overall		424

In the study, when the number of representations to NOS for textbooks was examined separately, the results obtained are shown in Figure 1. The findings showed that there were a total of 246 representations related to the NOS in Biology 9 textbook. While 165 of these representations are related to the cognitive-epistemic structure of science, 81 are related to the social-institutional aspect. The findings also showed that there were a total of 178 representations related to the NOS in Biology 10 textbook. While 82 of these representations are related to the cognitive-epistemic structure of science, 96 are related to the social-institutional aspect.

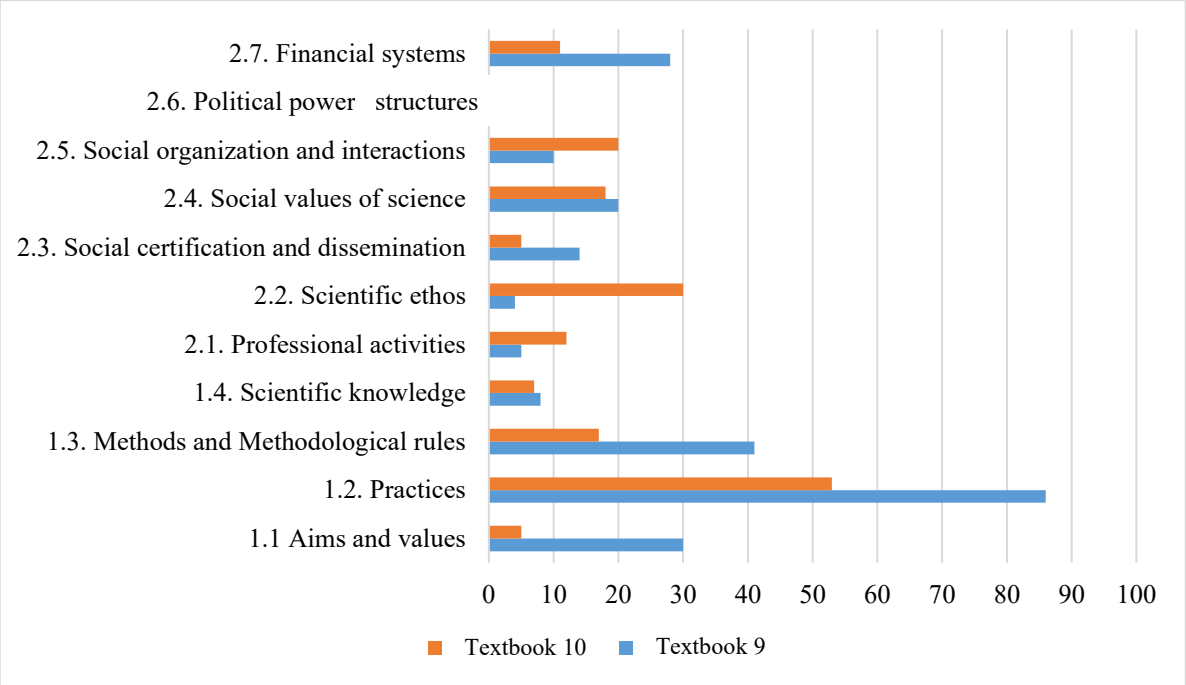

Figure 1. The Number of Representations to NOS for Textbooks

In addition to the above findings, while the most frequent representations in both textbooks were found in the scientific practices sub-dimension, the fewest representations were found in the political power structures sub-dimension. No representations about political power structures were found in either textbook. Regarding the cognitive-epistemological structure of science, it was determined that the scientific practices sub-dimension was most cited in both textbooks. It was determined that the fewest representations regarding the cognitive-epistemological structure of science were made in the scientific knowledge sub-dimension for Biology 9 textbook and in the aims and values sub-dimension for Biology 10 textbook. Regarding the social-institutional structure of

science, the most representations were found in the financial systems sub-dimensions in Biology 9 textbook and in the scientific ethos sub-dimensions in Biology 10 textbook. In addition, it was determined that the fewest representations were made in the scientific ethos sub-dimension for Biology 9 textbook and in the social certification and dissemination sub-dimension for Biology 10 textbook.

The study also examined which aspects of NOS were discussed more in biology textbooks according to chapters. The findings are shown in Figure 2 and Figure 3.

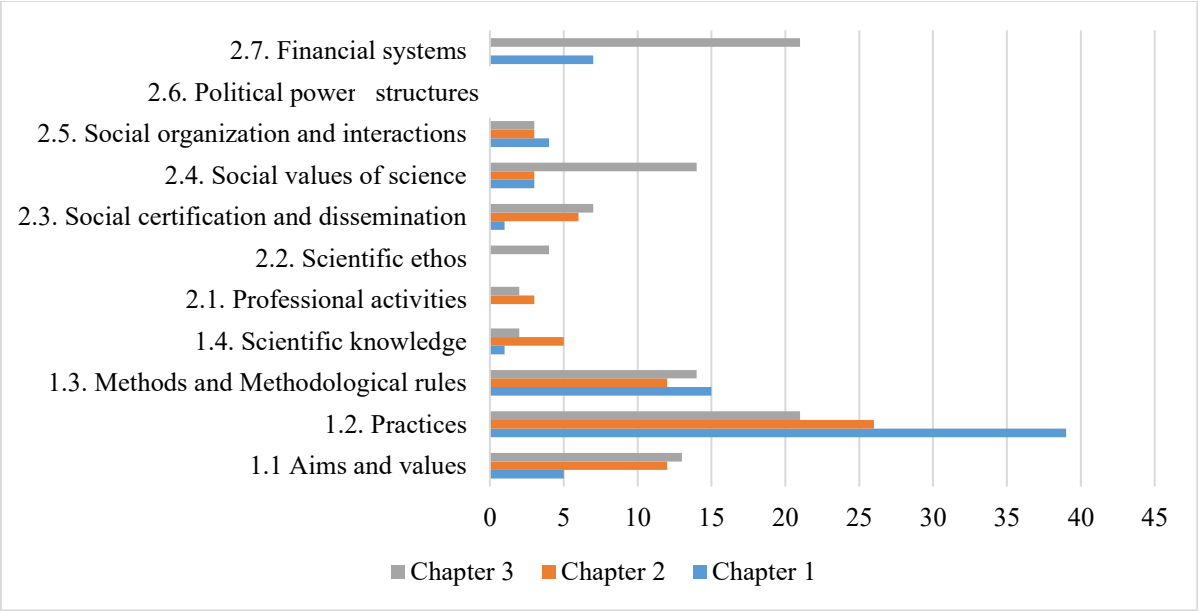

Figure 2. Distribution of NOS Representations for Biology 9 Textbooks by Chapters

The findings in Figure 2 showed that the most frequent representations to NOS in Biology 9 textbook were in the scientific practices sub-dimension in all three chapters. However, in all three chapters in the cognitive-epistemic dimension, it was determined that there were many representations to NOS in the sub-dimensions of methods and methodological rules and aims and values. When the findings regarding the social-institutional dimension are examined, the most representations to NOS were made in chapter 3 (World of the Living Things). Additionally, it is noteworthy that NOS is cited only in chapter 3 for the sub-dimension of scientific ethos. Again, it is seen that there are many representations in the sub-dimensions of financial systems and social values of science for chapter 3. Representations to NOS in other chapters are much less. The political power structures sub-dimension is not cited in all chapters. In the other sub-dimensions of the social-institutional dimension, NOS is cited at a very low level in all chapters, but especially chapter 1 (Life Science Biology) is at the lowest level. On the other hand, findings from Biology 10 textbook are shown in Figure 3.

The findings in Figure 3 showed that representations to NOS in the biology 10 textbook were mostly in chapter 3 (Ecosystem Ecology and Current Environmental Problems). However, the most frequent citation was found in the scientific ethics sub-dimension of the Social-Institutional dimension in chapter 3. Additionally, in chapter 3, the number of representations was high in the sub-dimensions of social organization and interactions, and social values of science. Although the number of representations in other chapters related to the Social-Institutional

dimension is at a lower level, it is especially at the lowest level in chapter 1. In none of the chapters were there any representations about NOS in the dimension of political power structures, which is one of the social and institutional sub-dimensions of science.

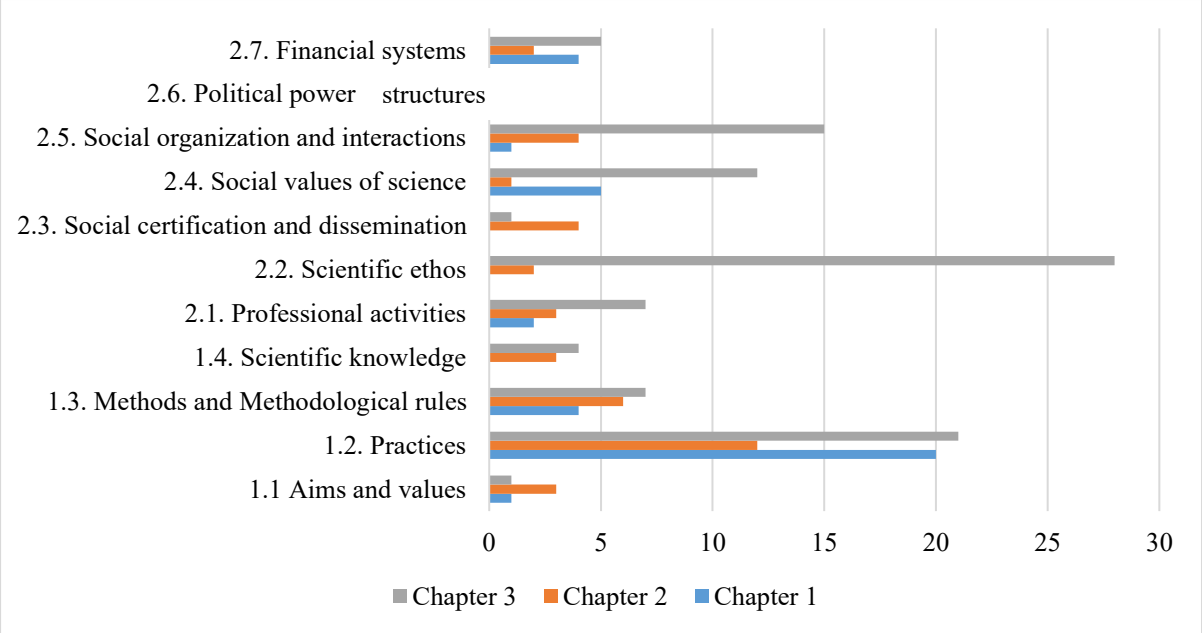

Figure 3. Distribution of NOS Representations for Biology 10 Textbooks by Chapters

Discussion and Recommendations

The purpose of this study is to examine how NOS is represented in 9th grade and 10th grade biology textbooks according to RFN and how this varies by grade level and chapters in the textbooks. The content analysis of biology textbooks according to RFN was conducted and the results were presented by examining to what extent NOS was reflected in the textbooks and how it was represented according to chapters. Preliminary findings showed that the total number of representations to NOS in both textbooks is 424. While 247 of these representations are related to the cognitive-epistemic structure of NOS, 177 are related to its social-institutional structure. According to these results, it can be said that in both textbooks, more references are made to the cognitive-epistemic dimension of NOS than to its social-institutional dimension. In Türkiye, textbooks are prepared by experts, most of whom are scientists. This may be a reason for the greater emphasis on the scientific-epistemological aspect of NOS in textbooks. In a recent study, Wu and Erduran (2024) sought the opinions of 17 Taiwanese scientists. The results of the study showed that scientists agreed with the RFN explanation of NOS and explained all aspects of NOS in detail, but the social-institutional aspects were not sufficiently represented in their descriptions. This finding is parallel to the findings of studies on current curriculum analyses and textbook analyses that use the RFN as an analytical framework (BouJaoude, Dagher & Refai, 2017; Çelik & Karataş, 2022; McDonald, 2017; Sayın, 2021; Yang, Park & Song, 2020). For example, Abd-El-Khalick et al. (2008) evaluated the representations of NOS in high school chemistry textbooks and the extent to which these representations have changed over the last forty years. Researchers stated that NOS was represented indirectly in the textbooks and that NOS statements in the textbooks could only be reached by making inferences. Kaya and Erduran (2016) analysed certain parts of the

science curriculum previously used in Türkiye. These researchers analysed 2006 and 2013 science curricula. According to the findings, while there are statements about the cognitive-epistemic system in the programs, statements about the social-institutional system are very limited. Similarly, Sayın (2021), Çelik and Karataş (2022) examined the textbooks on NOS and the findings for both studies showed that cognitive-epistemic dimension of NOS was cited more than social-institutional dimension. As stated by Wu and Erduran (2024), although this finding can be interpreted as the curriculum objectives having similar contents to scientists' views on NOS, the importance and applicability of these aspects in terms of learning can be investigated in future studies. On the other hand, the RFN categories discussed by Erduran and Dagher (2014) are not considered to be independent and exclusive from one another, but rather interact and dynamically relate to one another (Ramnarain, 2023). For example, social values may influence scientific ethics, or financial systems may mediate how epistemic goals and values are determined for scientific research. The interactive and complex NOS means that assigning aspects of science to separate categories can be difficult not only theoretically but also empirically (Wu & Erduran, 2024). Therefore, the social-institutional aspect of NOS could be given more space in textbooks. Another way to further integrate the social-institutional aspects of science into learning environments could be through the news media. News media can mediate the transmission and perception of scientific stories to the public (Cheung et al., 2023). For example, reading scientific newspaper articles may be a suitable didactic resource to support teachers' understanding of NOS and also to provide them with a possible teaching strategy to address some aspects of NOS in science classes. However, since newspaper articles are not usually written for educational purposes, it is necessary to evaluate their pedagogical usefulness before planning to read them in science classes (García-Carmona & Díaz, 2016). In addition, the news media also has important duties in terms of establishing and protecting public trust and encouraging public participation in science. At this point, the news media should avoid oversimplifying scientific studies and presenting them in a biased manner. Indeed, this situation has become more evident during the COVID-19 pandemic. Cheung et al. (2023) stated that the news media played a vital role in conveying scientific evidence to the public during the pandemic period and that it was important to persuade the public to comply with social distancing rules and respond to health campaigns such as vaccination programs. However, researchers criticized newspapers for focusing on the socio-political perspective of science without explaining the nature of the scientific studies behind government decisions. As a result, it can be said that the news media should be balanced in representing science as a cognitive-epistemic system and a social-institutional system (Erduran & Dagher, 2014).

In addition to the above, it was determined that the scientific practices sub-dimension of the cognitive-epistemic dimension was most cited in both textbooks. The findings from Sayın (2021), Çelik and Karataş (2022), Okan and Kaya (2023a) showed that the most representations were made in the scientific practices sub-dimension of the cognitive-epistemic dimension in the textbooks. Scientific practices are mostly presented as step-by-step activities in the activity section of textbooks (Okan & Kaya, 2023a). In the context of this category, it can be said that there is consistency between the curriculum and textbooks. According to Kurt and Kaya (2023), the reason why this category is so prominent may be due to the assumption that science can be learned better if scientific practices are taught. However, in order to learn science, it is critical to learn the whole science, not just a part of it (Allchin, 2011). Regarding the scientific-epistemic dimension in the study, NOS was cited most in the methodological methods and rules sub-dimension after scientific practices in both textbooks. However, the

striking point about this subcategory is the limited emphasis on different scientific methods in textbooks. Additionally, similar to the findings of this study, in Sayın's (2021) study, the themes of scientific practices, methodology and methodological rules were generally treated as isolated activities in the textbooks, and the research and activities expected from many students in the departments exhibited a prescription-style approach. Erduran and Kaya (2018) stated that in science education, activities such as experiments, observations and classification tend to be given in a disconnected manner that does not lead to modelling. Sayın (2021) also emphasized that a similar situation exists in high school textbooks and stated that most activities that students are expected to do tend to draw attention to the superficial features of science and are far from critical thinking. Therefore, especially the activity sections in textbooks should include activities that focus on the research strategies used in science, the tools used to communicate the results of research, and the role of collaborative work between scientists, along with knowledge of traditional concepts.

Regarding the social-institutional structure of science, Kurt and Kaya (2023) stated that a more limited inclusion of social-institutional categories in textbooks may cause problems for teaching the social-institutional aspects of science. Again, Kaya et al (2017) stated that science does not consist only of epistemic and cognitive components. Therefore, it is very important to focus on the social-institutional aspects of science in order to explain that there are some social and ethical values and economic and political power balances in the background of the scientific process. However, when the findings of the study are examined, it is striking that there are no representations to NOS in any of these categories, especially in the category of political power structures. Similar findings were also found in the literature (Çelik & Karataş, 2022; Park et al., 2019; Sayın, 2021). The culture and certain values (political factors) in which scientists live affect scientific initiatives and research activities. Moreover, it is suggested that including the financial dimension of NOS in lessons will increase students' participation in the learning process and increase the level of scientific literacy (Çelik & Karataş, 2022; Erduran & Dagher, 2014). Therefore, the lack of representations to political power structures in the biology textbooks examined in the study may negatively affect students' education as scientifically literate individuals. According to Çelik and Karataş (2022), the reason why political power structures are not included in textbooks is related to the way curriculum developers and textbook authors perceive science or NOS. Therefore, the preparation or updating of textbooks, including biology, is extremely important in terms of seeking new perspectives of field experts. Similarly, Erduran and Dagher (2014) determined the balance of political power, the dynamics of financial resources used in the scientific process, and the impact of various cultural values on the scientific process as parts of the value system that affects science. However, in many studies in the literature, it has been determined that the number of representations to NOS in textbooks in the sub-dimension of financial systems is quite limited (Kurt & kaya, 2023; Park et al., 2019). In fact, similar findings emerged in this study. However, in this study, the financial systems category is defined as a category of the financial systems sub-dimension. Therefore, when the findings were considered in terms of financial systems sub-dimensions, it was determined that NOS was cited more in the Biology 9 textbook. On the other hand, in the Biology 10 textbook, NOS was cited more in the scientific ethos sub-dimension. These findings may be related to the chapters in the textbooks. In the Biology 9 textbook, the most representations to NOS in financial systems sub-dimension were made in Chapter 3 (World of the Living Things). Scientists are increasingly involved in financing, marketing, commercialization and entrepreneurship and continue their work depending on these (Kaya et al., 2018; Okan & Kaya, 2023b). Accordingly, especially with the

developing science and technology today, the scientific use of many useful features of living things on earth, the role of some living species as models for the developed technological tools and their commercial value can also be considered among the subjects of the science economy. As a matter of fact, particularly the second topic of chapter 3 deals with the living world and its characteristics, and emphasizes the economic and social benefits of living things. Therefore, many representations to NOS were detected in the financial system sub-dimension. As a matter of fact, the fact that there are many representations to the social values of science in Chapter 3 supports this idea. Additionally, another reason for the high number of representations to NOS in this topic may be due to the large number of learning outcomes. As a result of a study conducted by Okan and Kaya (2023b), it is seen that the emphasis on NOS is greater in the chapter 6, which includes the subject area "Living Things and Life". According to Okan and Kaya (2023b), the reason for this may be that there are more learning outcomes in the chapter 6 of the science curriculum published by the MoNE compared to other chapter.

In the Biology 10 textbook, the most representations to NOS in scientific ethos sub-dimension were made in Chapter 3 (Ecosystem Ecology and Current Environmental Problems). When the topics in Chapter 3 (ecosystem ecology, current environmental problems and human, natural resources and biological diversity protection) are examined, it is seen that they contain important current problems that closely concern humanity and all living things. The environmental problems have brought striking results that lead people to be more sensitive to the environment and environmental problems, and awareness has increased even more. Following these developments, people began to feel more ethical responsibility towards the environment compared to previous periods, and they began to discuss environmental issues in the context of economy, ecology, sociology, philosophy, social justice and social policy (Akalın, 2022). At this point, the importance of education in overcoming environmental problems cannot be denied. As a matter of fact, this may be a reason for including more learning outcomes related to chapter 3 in our curriculum and more representations to the ethical dimension of science in textbooks. On the other hand, the increasing efforts of scientists to protect the environment and find solutions to problems along with education can be considered as a clear indicator of awareness on this issue. As a matter of fact, many references to the social values of science, social organization and interactions, and professional activities in chapter 3 support this idea. Because, especially in the analyses made in the Biology 10 textbook, it is seen that in these sub-dimensions, the studies of organizations such as TUIK, the World Health Organization and the Natural Life Protection Foundation are included, as well as the studies of important scientists in our country such as Aziz Sancar.

On the other hand, scientific ethos in chapter 3 of the Biology 10 textbook was widely cited, while the category of political power structures is not cited at all. As stated by McDonald (2017) and Çelik and Karataş (2022), these findings are an indication that the dimensions of the NOS that constitute RFN can be addressed independently of each other in textbooks (McDonald, 2017). According to Erduran et al. (2019), this can be considered an advantage of RFN. Another important finding of the study is that the social-institutional structure of science is cited less than the cognitive-epistemic structure in biology textbooks. Research suggests that in order to understand NOS at an adequate level, both social-institutional and cognitive-epistemic aspects of textbooks should be addressed (Fuselier, Jackson, & Stoiko, 2016; Okan & Kaya, 2023b). Teaching the epistemic, cognitive and social aims and values of science in science education can enable students to respect and internalize the values that should be

adopted in the process of obtaining and disseminating scientific knowledge (Allchin, 1999; Kaya et al., 2017). In addition, it is important to address these points in science teaching in order to increase students' cognitive ability levels and social awareness. One way to achieve this would be to introduce the social-institutional dimension of NOS into teacher training as well as textbooks or science education. As a result of the study conducted by Kaya et al. (2017), the change in teacher candidates' perceptions of NOS revealed how important it is to teach the nature of science in science lessons from a holistic perspective. Therefore, it is important to address RFN categories in courses given in teacher education in order to improve prospective teachers' understanding of NOS. Of course, it would be beneficial to present the epistemic, cognitive and social aspects of science in a holistic manner, not only in teacher education level, but also in science/biology curricula and textbooks at primary and secondary education levels. As stated, before in the study, representations to NOS were quite low in some dimensions. This may cause the student to learn these dimensions less. Therefore, awareness of these dimensions can be increased by conducting experimental studies.

Conclusion

In conclusion, it was revealed that biology textbooks in Türkiye do not include all aspects of science in a balanced way as it was found in the science curriculums (Kaya & Erduran, 2016; Kurt & Kaya, 2023; Okan & Kaya, 2023b; Özden & Cavlazoğlu, 2015). This situation may hinder the goal of raising scientifically literate individuals in many ways. First of all, emphasizing only the epistemic-cognitive aspect of science and neglecting the social and institutional aspects of science may lead students to see science as a static and unchanging body of knowledge. Neglecting the process dimension of science, which is affected by social and cultural dynamics and changes over time, may lead to a lack of understanding of the dynamic structure of science. Secondly, ignoring the fact that scientists work in cooperation with scientific communities may cause students to fail to comprehend that science is a collective and social endeavor rather than an individual endeavor. Thirdly, students' failure to understand the impact of science in social, political and economic contexts may result in their inability to comprehend how scientific knowledge can contribute to the solution of social problems. Finally, when social-institutional aspects are not emphasized sufficiently, scientific ethics and values may not be discussed sufficiently. This may make it difficult for students to understand the importance of adherence to ethical rules and values in scientific research. In order for students to understand science in a more holistic way and to gain a broader perspective on the processes of producing and applying scientific knowledge, it is necessary to include the social-institutional aspects of science as well as the cognitive-epistemic aspects of science in a balanced manner in teaching.

In order to help students better understand that science is not only theoretical knowledge but also a social and institutional process, various strategies and methods that have been found to be effective in the literature can be integrated into the science teaching process. The historical development of scientific concepts, their philosophical foundations, and the social, political and economic impact of scientific developments can be integrated into lessons to help students understand the dynamic nature of science and its social implications (Clough, 2018; Gandolfi, 2020; Koumara, 2024; Khishfe, 2023; Mccomas, 2008; Niaz, 2016). Students can be encouraged to undertake scientific inquiry projects that address real-world problems in order to gain in-depth understandings of how scientific knowledge is generated and applied (Abd-El-Khalick, 2013; Khishfe & Abd-El-Khalick, 2002;

Matkins, & Bell, 2007; Tsybulsky, 2018). Students can be encouraged to participate in discussions on socio-scientific issues that encourage them to generate scientific solutions to societal problems in different roles such as scientists, politicians and community members (Akbayrak, & Kaya, 2020; Herman, 2018). In these activities, NOS should be explicit, and students can be given the opportunity to work together in groups to solve scientific problems and understand scientific processes that require co-operation and collective effort.

References

Abd-El Khalick, F., & Lederman, N. G. (2000a). The influence of history of science courses on students' views of nature of science. *Journal of Research in Science Teaching, 37*(10), 1057-1095. https://doi.org/10.1002/1098-2736

Abd-El-Khalick, F., & Lederman, N. G. (2000b). Improving science teachers' conceptions of nature of science: a critical review of the literature. *International Journal of Science Education*, *22*(7), 665–701. https://doi.org/10.1080/09500690050044044

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. https://doi.org/10.1002/tea.20226

Abd-El-Khalick, F., Myers, J. Y., Summers, R., Brunner, J., Waight, N., Wahbeh, N., Zeineddin, A. A., & Belarmino, J. (2017). A longitudinal analysis of the extent and manner of representations of nature of science in US high school biology and physics textbooks. *Journal of Research in Science Teaching*, *54*(1), 82–120. https://doi.org/10.1002/tea.21339

Akalın, M. (2022). *Çevre etiği: Çevreye felsefi yönelimler* (Güncel Baskı). Iksad Publications.

Akerson, V. L., Buzzelli, C. A., & Donnelly, L. A. (2008). Early childhood teachers' views of nature of science: The influence of intellectual levels, cultural values, and explicit reflective teaching. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *45*(6), 748-770. https://doi.org/10.1002/tea.20236

Allchin, D. (1999). Values in science. *Science & Education, 8*, 1-12.

Allchin, D. (2011). Evaluating knowledge of (whole) science. *Science Education, 95*(3), 518-542. https://doi.org/10.1002/sce.20432

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. https://doi.org/10.1039/C5RP00073D

Bell, R. L., Matkins, J. J., & Gansneder, B. M. (2011). Impacts of contextual and explicit instruction on preservice elementary teachers' understandings of the nature of science. *Journal of Research in Science Teaching*, *48*(4), 414–436. https://doi.org/10.1002/tea.20402

Binns, I. C., & Bell, R. L. (2015). Representation of scientific methodology in secondary science textbooks. *Science & Education, 24*(7-8), 913-936.

BouJaoude, S., Dagher, Z. R., & Refai, S. (2017). *The portrayal of nature of science in Lebanese ninth grade science textbooks* (Edt. Mcdonald, C V., Abd-El Kahalic, F). In: Representations of nature of science in

school science textbooks: A global perspective (1st edt), 79-97.

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal, 9*(2), 27-40. https://doi.org/10.3316/QRJ0902027

Boyacıoğlu, Z. (2021). A comparative analysis of selected biology textbooks used in Turkey, focusing on genetics chapters and their inclusion of nature of science. Master thesis, İhsan Doğramacı Bilkent Üniversitesi, Ankara.

Campanile, M. F., Lederman, N. G., & Kampourakis, K. (2015). Mendelian genetics as a platform for teaching about nature of science and scientific inquiry: The value of textbooks. *Science & Education*, *24*(1-2), 205-225. https://doi.org/10.1007/s11191-013-9607-4

Checkley, K. (1997). International math and science study calls for depth, not breadth. *Education Update, 39*(1), 1.

Chen, B., Chen, S., Liu, H., & Meng, X. (2024). Examining the changes in representations of nature of science in Chinese senior high school chemistry textbooks. *Science & Education, 33*(2), 327-346.

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. https://doi.org/10.1007/s11191-019-00051-3

Corbin, J. & Strauss, A. (2008). B*asics of qualitative research: Techniques and procedures for developing grounded theory (3rd ed.)*. Thousand Oaks, CA: Sage.

Celik, S., & Bayrakceken, S. (2006). The effect of a "Science, Technology and Society" course on prospective teachers' conceptions of the nature of science. *Research in Science & Technological Education*, *24*(2), 255–273. https://doi.org/10.1080/02635140600811692

Celik, S., & Bayrakceken, S. (2012). The influence of an activity-based explicit approach on the Turkish prospective science teachers' conceptions of the nature of science. *Australian Journal of Teacher Education*, *37*(4), 75–95.

Çelik, S., & Karataş, F. Ö. (2022). Representation of nature of science in chemistry textbooks: Employing reconceptualized family resemblance approach as a framework. *Hacettepe University Journal of Education, 37*(3), 1200-1212. https://doi.org/10.16986/HUJE.2022.455

Cheung, K. K. C., & Erduran, S. (2023). A systematic review of research on family resemblance approach to nature of science in science education. *Science & Education, 32*(5), 1637-1673. https://doi.org/10.1007/s11191-022-00379-3

Cheung, K. K. C., Chan, H. Y., & Erduran, S. (2023). Communicating science in the COVID-19 news in the UK during Omicron waves: exploring representations of nature of science with epistemic network analysis. *Humanities and Social Sciences Communications, 10*(1), 1-14.

Chiappetta, E. L., Ganesh, T. G., Lee, Y.H., & Phillips, M. C. (2006, April). Examination of science textbook analysis research conducted on textbooks published over the past 100 years in the United States. *Paper presented at the annual meeting of the National Association for Research in Science Teaching*, San Francisco, CA.

Cofre, H., Nunez, P., Santibanez, D., Pavez, J. M., Valencia, M., & Vergara, C. (2019). A critical review of students' and teachers' understandings of nature of science. *Science & Education*, *28*(3–5), 205–248. https://doi.org/10.1007/s11191-019-00051-3

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*, *37*(6), 582–601. https://doi.org/10.1002/1098-2736(200008)37

Deng, F., Chen, D., Tsai, C., & Chai, C. S. (2011). Students' views of the nature of science: A critical review of research. *Science Education*, *95*(6), 961–999. https://doi.org/10.1002/sce.20460

Duruk, Ü., & Akgün, A. (2020). Bilimin doğası bileşenlerinin fen bilimleri ders kitaplarında temsil edilme durumu. *Amasya Üniversitesi Eğitim Fakültesi Dergisi*, *9*(2), 196-229.

Erdemir, A. Ü., & Özgür, S. D. (2023). Türkiye'de bilimin doğasi konusunda yapilan tezlere yönelik bir betimsel içerik analizi [A descriptive content analysis of theses investigating the nature of science in Türkiye]. *Elektronik Sosyal Bilimler Dergisi*, 22(86), 683-713. https://doi.org/10.17755/esosder.1224389

Erduran, S., & Dagher, Z. (2014). Reconceptualizing the nature of science for science education: Scientific knowledge, practices and other family categories. Dordrecht: Springer.

Erduran, S., & Kaya, E. (2018). Drawing nature of science in pre-service science teacher education: Epistemic insight through visual representations. *Research in Science Education, 48*(6), 1133-1149. https://doi.org/10.1007/s11165-018-9773-0

Erduran, S., Dagher, Z. R., & McDonald, C. V. (2019). Contributions of the family resemblance approach to nature of science in science education. *Science & Education, 28*(3-5), 311-328. https://doi.org/10.1007/s11191-019-00052-2

Fuselier, L. C., Jackson, J. K., & Stoiko, R. (2016). Social and rational: The presentation of nature of science and the uptake of change in evolution textbooks. *Science Education, 100*(2), 239-265. https://doi.org/10.1002/sce.21205

García-Carmona, A., & Acevedo Díaz, J. A. (2016). Learning about the nature of science using newspaper articles with scientific content: A study in initial primary teacher education. *Science & Education, 25*, 523-546.

Hazen, R. M., & Trefil, J. (2009). *Science matters: Achieving scientific literacy*. Anchor.

Hurd, P. D. (1998). Scientific literacy: New minds for a changing world. *Science Education*, *82*(3), 407–416. https://doi.org/10.1002/(SICI)1098-237X(199806)82:3<407::AID-SCE6>3.0.CO;2-G

Irez, S. (2009). Nature of science as depicted in Turkish biology textbooks. *Science Education, 93*(3), 422-447. https://doi.org/10.1002/sce.20305

Irzik, G., & Nola, R. (2014). *New directions for nature of science research*. In: M. Matthews (Ed.), International handbook of research in history, philosophy and science teaching (pp. 999-1021). Springer. https://doi.org/10.1007/978-94-007-7654-8_30

Kavak, N., Tufan, Y., & Demirelli, H. (2006). Fen-teknoloji okuryazarlığı ve informel fen eğitimi: Gazetelerin potansiyel rolü [Science and technology literacy and informal science education: Potential role of newspapers]. *Gazi Eğitim Fakültesi Dergisi, 26*(3), 17-28.

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 and Education*, *25*(9–10), 1115–1133. https://doi.org/10.1007/s11191-016-9861-3

Kaya, E., Erduran, S., Akgun, S., & Aksoz, B. (2017). Öğretmen eğitiminde bilimin doğası: Bütünsel bir yaklaşım [Nature of science in teacher education: A holistic approach]. *Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi, 11*(2), 464-501. https://doi.org/10.17522/balikesirnef.373423

Khine, M. S. (2019). Representations of nature of science in school science textbooks: A Global perspective. *Science & Education, 28*(3–5), 599–601. https://doi.org/10.1007/s11191-019-00025-5

Khishfe, R. (2023). Improving students' conceptions of nature of science: A review of the literature. *Science & Education*, *32*(6), 1887-1931. https://doi.org/10.1007/s11191-022-00390-8

Krippendorff, K. (2018). *Content analysis: An introduction to its methodology*: Sage publications.

Kurt, G., & Kaya, E. (2023). Toward a holistic vision on the nature of science in science curricula: an investigation of primary and middle school curricula in Turkey. *Research in Science & Technological Education*, 1-21. https://doi.org/10.1080/02635143.2023.2262400

Küçükoğuz, (2011). Exploring representation of nature of science aspects in 9th grade chemistry textbooks. Mater thesis, Orta Doğu Teknik Üniversitesi, Ankara.

Leach, J., Driver, R., Millar, R., & Scott, P. (1997). A study of progression in learning about "the nature of science": Issues of conceptualisation and methodology. *International Journal of Science Education*, *19*(2), 147–166. https://doi.org/10.1080/0950069970190202

Lederman, N.G. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching, 29*(4), 331-359.

Lederman, N. G. (2007a). Nature of science: Past, present, and future. In *Handbook of research on science education* (Vol. 2, pp. 831–879).

Lederman, N. G. (2007b). Pedagogy and the practice of science. *International Journal of Science Education*, *29*(7), 931–934.

Lederman, N. G., Lederman, J. S., & Antink, A. (2013). Nature of science and scientific ınquiry 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.

Matthews, M. (2012). Changing the focus: From nature of science (NOS) to features of science (FOS). In M. S. Khine (Ed.), *Advances in nature of science research* (pp. 3-26). Springer. https://doi.org/10.1007/978-94-007-2457-0_1

McComas, W.F., & Olson, J.K. (1998). *The nature of science in ınternational science education standards documents.* In: McComas, W.F. (eds) The nature of science in science education. Science & Technology Education Library, vol 5. Springer, Dordrecht. https://doi.org/10.1007/0-306-47215-5_2

McDonald, C. V. (2017). *Exploring representations of nature of science in australian junior secondary school science textbooks* (Edt. Mcdonald, C V., Abd-El Kahalic, F). In Representations of nature of science in school science textbooks: A global perspective (1st edt), 98-117.

McDonald, C. V., & Abd-El-Khalick, F. (2017). Representations of Nature of Science in School Science Textbooks. *Representations of Nature of Science in School Science Textbooks: A Global Perspective*, 1–19.

Meichtry, Y. J. (1992). The impact of science curricula on students views about the nature of science. *Journal of Research in Science Teaching, 30*(5), 429–443.

Miles, M. B., & Huberman, M. (1994). *Qualitative data analysis: A sourcebook of new methods* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Ministry of National Education [MoNE] (2018). Ortaöğretim kurumları biyoloji dersi öğretim programı, Talim terbiye kurulu başkanlığı [Secondary education institu-tions biology course curriculum, Educa-tion and

training board presidency]. 24 June, Available at: https://mufredat.meb.gov.tr/Dosyalar/20182215535566-Biyoloji%20d%C3%B6p.pdf

Okan, B., & Kaya, E. (2023a). Exploring the inclusion of nature of science in Turkish middle school science textbooks. *Science & Education, 32*(5), 1515-1535. https://doi.org/10.1007/s11191-022-00371-x

Okan, B., & Kaya, E. (2023b). 5. sınıf fen bilimleri ders kitabında bilimin doğası: Bütünsel bir yaklaşıma dayalı içerik analizi [Nature of science in the 5th grade science textbook: Content analysis based on a holistic approach]. *Gazi Üniversitesi Gazi Eğitim Fakültesi Dergisi, 43*(3), 1521-1560. https://doi.org/10.17152/gefad.1291416

Özden, M., & Cavlazoğlu, B. (2015). İlköğretim fen dersi öğretim programlarında bilimin doğası: 2005 ve 2013 programlarının incelenmesi [Nature of science in Turkish elementary science education curriculum: An investigation of 2005 and 2013 curricula]. *Eğitimde Nitel Araştırmalar Dergisi, 3*(2), 40-65. https://doi.org/10.14689/issn.2148-2624.1.3c2s3m

Park, W., Yang, S., & Song, J. (2019). When modern physics meets nature of science the representation of nature of science in general relativity in new korean physics textbooks. *Science & Education, 28*(9-10), 1055-1083. https://doi.org/10.1007/s11191-019-00075-9

Ramnarain, U. D., & Chanetsa, T. (2016). An analysis of South African Grade 9 natural sciences textbooks for their representation of nature of science. *International Journal of Science Education, 38*(6), 922-933. https://doi.org/10.1080/09500693.2016.1167985

Ramnarain, U. (2023). The inclusion of nature of science in south african life sciences and physical sciences school curricula. *International Journal of Science and Mathematics Education*, 1-15. https://doi.org/10.1007/s10763-023-10415-5.

Ryder, J., Leach, J., & Driver, R. (1999). Undergraduate science students' images of science. *Journal of Research in Science Teaching*, *36*(2), 201–219. <Go to ISI>://000078424700006

Sanchez, G., & Valcarcel, M. V. (1999). Science teachers' views and practices in planning for teaching. *Journal of Research in Science Teaching, 36*(4), 493-513.

Sardag, M., Aydin, S., Kalender, N., Tortumlu, S., Çiftçi, M., & Perihanoglu, S. (2014). The integration of nature of science in the new secondary physics, chemistry, and biology curricula. *Egitim ve Bilim, 39*(174), 233-248.

Sayın, Ö. (2021). Biyoloji, kimya ve fizik ders kitaplarında bilimin doğası: Yeniden kavramsallaştırılmış aile benzerliği yaklaşımı kullanılarak yapılan bir inceleme [Yayınlanmamış yüksek lisans tezi]. Marmara Üniversitesi.

Şahin, M. (2015). The analysis of the views of teachers related to the functions of teaching materials during the teaching-learning process. *Kastamonu Education Journal, 23*(3), 995-1012.

Turan, E., & Dogan, O. (2022). Dokuzuncu sınıf fen ders kitaplarında bilimsel sorgulama [Scientific ınquiry in 9th grade science textbooks]. *Marmara Üniversitesi Atatürk Eğitim Fakültesi Eğitim Bilimleri Dergisi, 56*(56), 135-157.

Turgut, H. (2007). Scientific literacy for all. *Ankara University Journal of Faculty of Educational Sciences, 40*(2), 233-256.

Ünlü Sinnett Jr, Ü. (2021). Representation of nature of science in science textbooks of the last 20 years. Yüksek Lisans tezi, Yıldız Teknik Üniversitesi, İstanbul.

Ültay, E., Akyurt, H., & Ültay, N. (2021). Sosyal bilimlerde betimsel içerik analizi [Descriptive content analysis in social sciences]. *IBAD Sosyal Bilimler Dergisi, 10*, 188-201. https://doi.org/10.21733/ibad.871703

Vojíř, K., & Rusek, M. (2019). Science education textbook research trends: A systematic literature review. *International Journal of Science Education, 41*(11), 1496-1516.

Wang, H. A. (1998). *Science Textbook Studies Reanalysis: Teachers*. Paper presented at the National Association for Research in Science Teaching, San Diego.

Wu, J. Y., & Erduran, S. (2024). Investigating scientists' views of the family resemblance approach to nature of science in science education. *Science & Education, 33*(1), 73-102.

Yang, S., Park, W., & Song, J. (2020). *Representations of nature of science in new Korean science textbooks: The case of 'scientific inquiry and experimentation'*. In Science Education in the 21st Century (pp. 19-35). Springer, Singapore.

Yeh, Y. F., Erduran, S., & Hsu, Y. S. (2019). Investigating coherence about nature of science in science curriculum documents: Taiwan as a case study. *Science & Education*, *28*, 291-310. https://doi.org/10.1007/s11191-019-00053-1

Author Information

Seyda Gul

https://orcid.org/0000-0003-4005-2158

Atatürk University

Türkiye

Contact e-mail: *seydagul@atauni.edu.tr*

Suat Celik

https://orcid.org/0000-0001-9858-2165

Atatürk University

Türkiye