

EXPLORING THE REPRESENTATION OF THE NATURE OF SCIENCE
IN SCIENCE TEXTBOOKS

by

Beyza Okan

B.S., Science Education, Boğaziçi University, 2019

Submitted to the Institute for Graduate Studies in
Science and Engineering in partial fulfillment of the
requirements for the degree of
Master of Science

Graduate Program in Mathematics and Science Education
Boğaziçi University

2021

Dedicated to my grandparents Saliha and Mustafa Okan

ACKNOWLEDGEMENTS

I would like to offer my special thanks to all those whose support and guidance was priceless in the completion of this thesis. First and foremost, I am extremely grateful to my supervisor, Prof. Ebru Kaya for her invaluable advice, continuous support, in-depth knowledge, motivation, and patience during my study. It is my greatest chance to work with a supervisor who supported me in every sense during this process and made my progress easier thanks to her discipline and became a great role model for me. I would like to express my endless gratitude to her for improving my research and academic skills, guiding me in every field, supporting me to participate in national and international conferences, and giving me constructive feedback at every stage of my study.

Besides my advisor, I would like to thanks to the rest of my thesis committee who are Prof. Sibel Erduran, and Assist. Prof. Olga Gkioka for their acceptance of being a jury member for my thesis, their encouragement, and insightful comments and suggestions contributing to shape and complete this thesis. Working with them has been a pleasure for me.

This thesis is a part of the project. I would like to acknowledge Bogazici University Research Fund (Grant Number: 17142) which supported this project entitled “Science Textbooks Analysis, and Relationship between Understanding of Nature of Science and Metacognitive Awareness”. I would like to extend my sincere thanks to my project teammates who are Büşra Aksöz and Dilara Gören for the stimulating discussion and feedback, for the sleepless night we were working together before deadlines, long voicemails we send to bounce back when we lose our motivation and lastly for all the fun we have had. Luckily, you were always with me during this process. This is not the end; I believe that we will be together in many studies in the future. In addition, I would like to thank my friend Selin Akgün, who spared time for me and contribute to shaping my analysis rubric despite her busy schedule and Nurdan Turan for her patience and support to make this thesis correctly in terms of format.

Endless thanks to my dear friends Elif Nur Serçe and Semanur Çakır, who are just one call away, ask how my thesis is going and how I feel, whenever I feel tired during this process. It was inestimable for me to feel mentally strong while studying thanks to their support and encouragement. They have always been with me in this process, as they have always been with me in every moment of my life. I am so grateful for not leaving me alone in this process. I am very lucky to have them.

Last but not least, I would like to express my gratitude to my parents Şafak and Güngör Okan for their encouragement, love, pray and sacrifices for educating and preparing me for my future. Without their tremendous understanding and encouragement during this process, it would be impossible for me to complete this thesis. I am very grateful that they have believed in me and have done their best to make me feel better in the process. Thanks to my dear mother who served me fruits and delicious foods to be stronger physically and mentally in this process and who stayed with me on my sleepless nights. Also, I cannot forget the priceless support of my little sister Saliha Burcu, who always makes me cookies and filter coffee while I have studied, and my dear brother Taha, who encouraged me whenever I feel demotivated.

ABSTRACT

EXPLORING THE REPRESENTATION OF THE NATURE OF SCIENCE IN SCIENCE TEXTBOOKS

This study relies on the Reconceptualized Family Resemblance Approach to Nature of Science (RFN) (Erduran & Dagher, 2014a; Kaya & Erduran, 2016). The study aims to examine the representation of NOS in 5th, 6th, 7th and 8th-grade science textbooks. Also, exploring the science teachers' perceptions of NOS, their textbook usage to teach NOS and their suggestions to integrate NOS in textbooks are another focus of the study. Four textbooks given to all middle school students freely by the Ministry of National Education of Turkey were analyzed through content analysis. Coding units which are sentences, steps of activities, etc. in the content, activity, and assessment sections of the textbooks were traced in the light of the keywords created by Kaya and Erduran (2016). Also, new keywords were generated during the analysis. Then, 8 science teachers were selected purposively, and semi-structured interviews were conducted. "NOS Questionnaire" developed by Kaya *et al.* (2019) was administrated to teachers. Thematic analysis and descriptive analysis were completed for analyzing data from interviews and questionnaire respectively. As a result of the textbook analysis, it was found that the textbooks do not explicitly represent the NOS, but scientific practices, social certification and dissemination, and professional activities are more emphasized in activities sections of all textbooks. But still, there is a need to integrate explicit references in the content sections of the textbooks. Teachers' perception and understanding of NOS, in general, were found high, but some teachers were found to have naive understandings of the scientific practices, methods and methodological rules, and professional activities. Almost all of the teachers stated that they do not use textbooks to teach NOS because the textbooks lack of including NOS adequately. They offered suggestions to include NOS in textbooks such as integration of the history of science, technology, questions, and activities to teach NOS explicitly. Overall, the study has implications for the integration of NOS holistically in science textbooks.

ÖZET

FEN BİLİMLERİ DERS KİTAPLARINDAKİ BİLİMİN DOĞASI TEMSİLİNİN İNCELENMESİ

Bu çalışma, Yeniden Kavramsallaştırılmış Aile Benzerliğine Dayalı Bilimin Doğası (RFN) yaklaşımına dayanmaktadır (Erduran ve Dagher, 2014a; Kaya ve Erduran, 2016). Çalışma, bilimin doğasının 5., 6., 7., ve 8. sınıf fen ders kitaplarındaki temsilini incelemeyi amaçlamaktadır. Ayrıca, fen bilimleri öğretmenlerinin bilimin doğası algılarını, bilimin doğasını öğretmek için ders kitabı kullanımını ve bilimin doğasını ders kitaplarına entegre etme konusundaki önerilerini incelemek çalışmanın başka bir odak noktasıdır. MEB tarafından onaylanan 4 ders kitabı içerik analiziyle incelenmiştir. Kitaplardaki içerik, etkinlik ve değerlendirme bölümlerinde yer alan cümleler, etkinlik basamakları gibi kodlama birimleri Kaya ve Erduran (2016) tarafından oluşturulan anahtar kelimeler ışığında taranmıştır. Analiz sırasında yeni anahtar kelimeler de oluşturulmuştur. Daha sonra 8 fen bilgisi öğretmeni ile yarı yapılandırılmış görüşmeler yapılmıştır. Kaya ve diğerleri (2019) tarafından geliştirilen “Bilimin Doğası Anketi” öğretmenlere uygulanmıştır. Görüşmelerden ve anketlerden elde edilen verilerin analizi için sırasıyla tematik analiz ve betimsel analiz yöntemleri kullanılmıştır. Ders kitabı analizi sonucunda ders kitaplarının bilimin doğasını açıkça temsil etmediği, ancak tüm ders kitaplarının etkinlik bölümlerinde bilimsel pratikler, sosyal kabul ve dağılım ve profesyonel aktivitelere daha fazla vurgu yapıldığı görülmüştür. Yine de ders kitaplarının içerik bölümlerine bilimin doğasına ait referansları açıkça entegre etme ihtiyacı vardır. Öğretmenlerin genel olarak bilimin doğası algı ve anlayışları yüksek bulunsa da bazı öğretmenlerin bilimsel pratikler, bilimsel yöntemler ve profesyonel aktiviteler hakkında naif bir anlayışa sahip oldukları görülmüştür. Öğretmenlerin çoğu bilimin doğasını öğretmek için ders kitaplarını kullanmadıklarını, çünkü ders kitaplarının bilimin doğasını yeterince içermediğini belirtmişlerdir. Öğretmenler bilimin doğasını açıkça öğretmek için kullanılabilecek bilim tarihinden örneklerin, teknolojik araçların, soru ve aktivitelerin ders kitaplarına dâhil edilmesini önermiştir. Sonuç olarak, bu çalışma bilimin doğasının fen ders kitaplarına bütünsel olarak entegrasyonu için öneriler sunmaktadır.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS	iii
ABSTRACT.....	v
ÖZET	vi
LIST OF FIGURES	xi
LIST OF TABLES	xiii
LIST OF ACRONYMS/ABBREVIATIONS	xiv
1. INTRODUCTION	1
1.1. Purpose of the Study	4
1.2. Research Questions.....	4
1.3. Significance of the Study	5
1.4. Operational Definitions of the Key Terms	8
2. LITERATURE REVIEW	11
2.1. Nature of Science in Science Education	11
2.2. Reconceptualized Family Resemblance Approach to Nature of Science (RFN)	16
2.3. RFN Categories.....	20
2.3.1. Aims and Values.....	20
2.3.2. Scientific Practices.....	24
2.3.3. Methods and Methodological Rules	26
2.3.4. Scientific Knowledge.....	28
2.3.5. Science as a Social-Institutional System	31
2.4. The Studies Conducted Based on RFN.....	34
2.5. The Role of Science Textbooks in Science Instruction	37

2.6. Portrayal of NOS in Science Textbooks	39
2.7. Summary of the Literature Review	44
3. METHODOLOGY	46
3.1. Research Design	46
3.2. Data Sources	47
3.2.1. Textbooks.....	47
3.2.2. Teacher Interviews.....	47
3.2.3. NOS Questionnaire	49
3.3. Sampling	49
3.3.1. Sampling of Textbooks	50
3.3.2. Sampling of Teachers	52
3.4. Data Analysis	52
3.4.1. Content Analysis of Science Textbooks	53
3.4.1.1. Selecting Unit of Analysis.	54
3.4.1.2. Analytical Framework.	55
3.4.1.3. Analysis Procedures.....	56
3.4.2. Thematic Analysis of Teacher Interviews	58
3.4.3. Descriptive Analysis of NOS Questionnaire	59
3.5. Trustworthiness.....	59
3.6. Ethical Considerations	61
4. RESULTS	62
4.1. Results of the Content Analysis of the Science Textbooks	62
4.1.1. Overall Evaluation of NOS in the Science Textbooks	62
4.1.1.1. Overall Evaluation of NOS in the 5th-Grade Science Textbooks.	62
4.1.1.2. Overall Evaluation of NOS in the 6th-Grade Science Textbook.....	66

4.1.1.3. Overall Evaluation of NOS in the 7th-Grade Science Textbook.....	68
4.1.1.4. Overall Evaluation of NOS in the 8th-Grade Science Textbook.....	71
4.1.1.5. Progression of NOS in the Science Textbooks.....	75
4.1.2. The Representation of NOS in the Science Textbooks.....	76
4.1.2.1. The Representation of NOS in the 5th-Grade Science Textbook.....	76
4.1.2.2. The Representation of NOS in the 6th-Grade Science Textbook.....	85
4.1.2.3. The Representation of NOS in the 7th-Grade Science Textbook.....	97
4.1.2.4. The Representation of NOS in the 8th-Grade Science Textbook.....	109
4.1.2.5. Summary of the Representation of NOS in Each Science Textbook.	120
4.2. Results of the Science Teachers' Perceptions on NOS and Science Textbooks	120
4.2.1. NOS Understanding and Perceptions of the Science Teachers	121
4.2.1.1. Quantitative Results.....	121
4.2.1.2. Qualitative Results.....	122
4.2.2. Science Teachers' Perceptions of Using Science Textbooks	126
4.2.2.1. Using Science Textbooks in Science Lessons.	127
4.2.2.2. Using Alternative Science Textbooks in Science Lessons.	128
4.2.2.3. Importance of Teaching NOS.....	129
4.2.2.4. Using Science Textbooks to Teach NOS.....	130
4.2.3. Science Teachers' Perceptions and Suggestions on Representation of NOS in Science Textbooks	131
4.2.3.1. Epistemic and Cognitive Aspects of Science.	131
4.2.3.2. Social- Institutional Aspects of Science.	134
4.2.4. Summary of the Teacher Interview Results.....	138
5. DISCUSSION	140
5.1. Discussion of the Results.....	140

5.1.1. Content Analysis of the Science Textbooks	140
5.1.1.1. Epistemic and Cognitive Aspects of Science.	141
5.1.1.2. Social-Institutional Aspects of Science.	145
5.1.1.3. Science, Engineering, Entrepreneurship Applications (SEEA).....	147
5.1.2. Science Teachers' Perceptions on NOS and Science Textbooks	150
5.1.2.1. Discussion of the Teachers' Understanding and Perceptions of NOS.....	150
5.1.2.2. Discussion of the Teachers' Perceptions of Using Science Textbooks.	151
5.1.2.3. Discussion of the Teachers' Perceptions and Suggestions on Representation of NOS in Science Textbooks.....	153
5.2. Implications of the Study	155
5.3. Limitations and Future Research	157
REFERENCES	159
APPENDIX A: INTERVIEW QUESTIONS FOR SCIENCE TEACHERS (ENGLISH)	183
APPENDIX B: INTERVIEW QUESTIONS FOR SCIENCE TEACHERS (TURKISH)	186
APPENDIX C: NATURE OF SCIENCE QUESTIONNAIRE.....	189
APPENDIX D: THE CONTENT OF THE 5 th -GRADE SCIENCE TEXTBOOK.....	194
APPENDIX E: THE CONTENT OF THE 6 th -GRADE SCIENCE TEXTBOOK	196
APPENDIX F: THE CONTENT OF THE 7 th -GRADE SCIENCE TEXTBOOK.....	201
APPENDIX G: THE CONTENT OF THE 8 th -GRADE SCIENCE TEXTBOOK.....	205
APPENDIX H: SCIENCE TEXTBOOK CODING RUBRIC	208
APPENDIX I: INFORMED CONSENT FORM.....	213
APPENDIX J: PERMISSION FOR FIGURES.....	215

LIST OF FIGURES

Figure 2. 1. FRA Wheel.....	19
Figure 2. 2. Epistemic, Cognitive And Social Aims and Values in Science.	21
Figure 2. 3. Benzene Ring Heuristic of Scientific Practices.....	26
Figure 2. 4. The ‘Gears’ Image of Scientific Methods and Their Relations.....	28
Figure 2. 5. Theory, Law and Model (TLM).	30
Figure 3. 1. Preparation, Organizing and Reporting Phases of the Study.	53
Figure 3. 2. Structured Analysis Matrix.	57
Figure 4. 1. The Frequency of the Codes for Each RFN Category in the 5 th -Grade Science Textbook.....	63
Figure 4. 2. The Frequency of the RFN Codes for Each Unit of the 5 th -Grade Science Textbook.	64
Figure 4. 3. The Frequency of the Codes for Content, Activity and Assessment Sections of the 5 th -Grade Science Textbook.....	65
Figure 4. 4. The Frequency of the Codes for Each RFN Category in the 6 th -Grade Science Textbook.	66

Figure 4. 5. The Frequency of the RFN Codes for Each Unit of the 6 th -Grade Science Textbook.	67
Figure 4. 6. The Frequency of the Codes for Content, Activity and Assessment Sections of the 6 th -Grade Science Textbook.....	68
Figure 4. 7. The Frequency of the Codes for Each RFN Category in the 7 th -Grade Science Textbook.	69
Figure 4. 8. The Frequency of the RFN Codes for Each Unit of the 7 th -Grade Science Textbook.	70
Figure 4. 9. The Frequency of The Codes for Content, Activity and Assessment Sections of the 7 th -Grade Science Textbook.....	71
Figure 4. 10. The Frequency of the Codes for Each RFN Categories in the 8 th -Grade Science Textbook.	72
Figure 4. 11. The Frequency of the RFN Codes for Each Unit of the 8 th -Grade Science Textbook.	73
Figure 4. 12. The Frequency of the Codes for Content, Activity and Assessment Parts of the 8 th -Grade Science Textbook.	74
Figure 4. 13. The Frequency of the Codes Showing the Progression of NOS in Science Textbooks.....	75

LIST OF TABLES

Table 2. 1. Application of epistemic-cognitive and social aims and values of science in science education.	23
Table 3. 1. Distribution of interview questions.	49
Table 3. 2. Content of 5 th , 6 th , 7 th , and 8 th -grade science textbooks.....	51
Table 3. 3. Brief descriptions of RFN categories.	55

LIST OF ACRONYMS/ABBREVIATIONS

AV	Aims and Values
EIN	Education Information Network
FRA	Family Resemblance Approach
FS	Financial Systems
M	Methods and Methodological Rules
MEB	Milli Eğitim Bakanlığı
MoNE	Ministry of National Education
NOS	Nature of Science
PA	Professional Activities
PPS	Political Power Structures
RFN	Reconceptualized Family Resemblance Approach to NOS
SCD	Social Certification and Dissemination
SE	Scientific Ethos
SEEA	Science, Engineering, and Entrepreneurship Applications
SK	Scientific Knowledge
SOI	Social Organizations and Interactions
SP	Scientific Practices
SV	Social Values

1. INTRODUCTION

Nature of Science (NOS) has been emphasized a lot in science education within past few decades (Leden & Hansson, 2019; Matthews, 2012; McComas & Olson, 1998). Understanding of NOS is necessary to generate scientifically literate students (Holbrook & Rannikmae, 2007). Being scientifically literate provides humans to understand how scientific knowledge is generated in addition to being aware of the subject matter of science (Lederman *et al.*, 2014). However, some individuals still have insufficient understanding to explain how scientific enterprise runs. The lack of NOS understanding can affect the individuals who have rights to speak on scientific or policy issues and share their ideas in the decision-making process negatively. The aim of understanding NOS is to generate scientifically literate citizens and promote public understanding of science (Driver *et al.*, 1996). Driver and her colleagues (1996) explained public understanding of science as “understanding some aspects of science content, understanding the scientific approach to inquiry and understanding science as a social enterprise” (Driver, Leach, Millar, & Scott, 1996, p.25).

Understanding nature and history of science has become a crucial issue in some curriculum documents such as American Association for the Advancement of Science (AAAS, 1990) and National Research Council (NRC, 1996). Besides, science educators who conducted research on science education have come to mutual understanding on how important it is to understand the nature of science (NRC, 2012). In many science curricula there is an emphasis on raising all students from primary to high school as scientifically literate which requires teaching the nature of science at each grade level. Abd-El-Khalick and his colleagues discuss that some tenets referring to consensus view are suitable and useful for all grade levels from primary to high school to understand the nature of science (Abd-El-Khalick *et al.*, 1998; Lederman & Lederman, 2004). Hence, it is important to integrate nature of science in science education in each grade level to provide better understanding of NOS.

School science makes the greatest contribution to educational curricula aiming at educating students as scientifically literate. Most of the studies which were carried out with different groups of students in different contexts lead us to a common conclusion that students do not understand NOS adequately or adopt naive understandings (Lederman & O'Malley, 1990; Ryan & Aikenhead, 1992; Ryder *et al.*, 1999). Many researchers argue that one of the reasons underlying the insufficient understanding of students and teachers about the nature of science is that the dimensions of the nature of science are not sufficiently integrated in science textbooks (Abd-El-Khalick & Akerson, 2004; Bianchini & Colburn, 2000). Textbooks are actively used by science teachers in science classes for different purposes such as giving homework, designing lessons or deciding sequence of topics (Chiappetta *et al.*, 1991; McDonald, 2016; Stake & Easley, 1978). Therefore, science textbooks should include the objectives and contents related to nature of science in a balanced and sufficient ways (Sahin & Köseoglu, 2016).

In addition, curriculum reforms made in Turkey since 2004 aim to generate students as scientifically literate citizens to support the development of the country (Özden & Cavlazoğlu, 2015). However, when we look at the curriculum studies conducted in Turkey, it is seen that the aspects of the nature of science are not included in the science curricula in a balanced and adequate way (Kaya & Erduran, 2016; Özden & Cavlazoğlu, 2015). In this context, textbooks that serve as a bridge between the curriculum and students should be examined in order to understand how the Turkish science textbooks used in the lessons reflect the nature of science and how much teachers use them to teach the nature of science.

Although most of the researchers support the importance of understanding of NOS, there are some researchers have defined understanding of NOS from different perspectives. Collette and Chiappetta (1984) used four categories to describe scientific literacy which is related to NOS. Then, Garcia (1985) have validated an approach including some categories and descriptors such as “science as a body of knowledge”, “science as a way of investigation”, “science as a way of thinking” and “science and its interaction with technology and society” in order to examine the representation of NOS in science textbooks.

Another framework called consensus view including some tenets such as “the tentative nature of scientific knowledge”, “observation, inference and theoretical entities in

science”, “the theory-laden nature of scientific knowledge”, “the creative and imaginative nature of scientific knowledge”, “the social and cultural embeddedness of scientific knowledge”, “scientific theories and laws” and, “myth of the scientific method” has been studied by many researchers in many years (Akerson & Donnelly, 2008; Abd-El-Khalick & Lederman, 2000a; Lederman *et al.*, 2002; McComas, 1998).

Although consensus view has been the basis of studies on the nature of science for years, this understanding has been criticized by many philosophers and researchers of science education (Duschl & Grandy, 2011; Erduran & Dagher, 2014a; Yacoubian, 2012). As a result of these criticisms, different frameworks about the nature of science have emerged such as “Whole Science” by Allchin (2011) “Features of Science (FOS)” by Matthews (2012), “Family Resemblance Approach to Nature of Science (FRA)” by Irzik and Nola (2011, 2014). Besides, “Reconceptualized Family Resemblance Approach to NOS (RFN)” was proposed by Erduran and Dagher (2014a) and named by Kaya and Erduran (2016).

RFN is a new approach that explains science as a cognitive, epistemic and social-institutional system. Although there are different alternative frameworks to consensus view, RFN is more strong approach that can be used to learn and teach NOS holistically by considering domain- specificity and domain-general features of science (Erduran & Dagher, 2014a). Hence, the theoretical basis of this study is Reconceptualized Family Resemblance Approach to Nature of Science (RFN) which defines epistemic, cognitive aspects of science in a holistic way such as “aims and values (AV)”, “scientific practices (SP)”, “methods and methodological rules (M)”, “scientific knowledge (SK)” and social institutional aspects of science such as “professional activities (PA)”, “scientific ethos (SE)”, “social values (SV)”, “social certification and dissemination (SCD)”, “social organizations and interactions (SOI)”, “political power structures (PPS)” and “financial systems (FS)” (Erduran & Dagher, 2014a).

There are limited studies conducted by depending on Reconceptualized Family Resemblance Approach to NOS (RFN) because it is new approach. There are some studies for curriculum analysis (e.g., Erduran & Dagher, 2014b; Kaya & Erduran, 2016; Park *et al.*, 2019; Yeh *et al.*, 2019), in-service and preservice teachers’ understanding of NOS (e.g.,

Aksoz, 2018; Erduran, Kaya, & Dagher, 2018; Cullinane, 2018; Kaya *et al.*, 2019; Kelly & Erduran, 2019; Saribas & Ceyhan, 2015) and middle schoolers' NOS understanding (e.g., Akbayrak & Kaya, 2020; Cilekrenkli, 2019; Karabas, 2017). In addition to these studies, there are two textbook analyzes which were conducted with Lebanese and Australian science textbooks (e.g., BouJaoude *et al.*, 2017; McDonald, 2017). Textbook analysis which was conducted based on RFN is limited to give a general idea of how much the nature of science is included in science textbooks. Therefore, the textbooks used in different countries and grade levels should be examined in order to present the representation of NOS.

1.1. Purpose of the Study

The study aims to examine (a) the representation of Reconceptualized Family Resemblance Approach to Nature of Science (RFN) in 5th, 6th, 7th and 8th grade science textbooks (b) science teachers' understanding and perceptions of NOS including set of categories, (c) science teachers' perceptions of using science textbooks in addressing NOS and (d) science teachers' perceptions and suggestions on representation of NOS in science textbooks.

1.2. Research Questions

This subsection includes research questions of the study.

1. How do Turkish middle school science textbooks represent the Reconceptualized Family Resemblance Approach to Nature of Science (RFN)?
 - 1.1. What extent does 5th grade science textbook represent the RFN?
 - 1.2. What extent does 6th grade science textbook represent the RFN?
 - 1.3. What extent does 7th grade science textbook represent the RFN?
 - 1.4. What extent does 8th grade science textbook represent the RFN?
2. How do science teachers perceive and understand the Nature of Science (NOS) in terms of aims and values, scientific practices, methods, scientific knowledge and social-institutional systems of science?

3. What are science teachers' perceptions of using science textbooks in addressing NOS?
4. What are science teachers' perceptions and suggestions on representation of NOS in science textbooks?

1.3. Significance of the Study

Learning the nature of science in depth allows students to understand how science works. (Allchin, 2011). Although science policy documents argue that understanding of nature of science is very effective in raising students as scientific literate and aim of science education is to promote students to improve understanding of NOS adequately, many studies have found that students have naive views on NOS (Abd-El-Khalick & Lederman, 2000b; Khishfe & Abd-El-Khalick, 2002). One of the reasons for this issue can be that the textbooks actively used in the lessons do not contain the nature of science explicitly. Although textbooks provide a basis for both teaching and learning, it is not always a sufficient tool to obtain high quality knowledge (Zajkov *et al.*, 2017). Providing students with an understanding of nature of science in an authentic way, teaching what science is and how it works, is particularly challenging for middle school teachers. In order to improve students' understanding of NOS, textbooks that teachers use in lessons should reflect and present the nature of science in a balanced way (Chiappetta *et al.*, 1993). In order to understand whether science textbooks serve this purpose and how much science textbooks contain the nature of science should be examined (Lee, 2014).

Textbook in Turkey is a tool used in order to ensure an easier way of tracking the curriculum. Hence, textbooks seen as an integral part of education should include the content of the curriculum in the best way without any misconceptions (Sülükçü, 2018). Kaya and Erduran (2016) conducted a research to examine the representation of NOS based on RFN in two Turkish science curricula. The findings of curricula analysis showed that there is representation of some RFN categories in Turkish curriculum documents whereas some categories were missed. Each curriculum generally refers the cognitive and epistemic aspects of science. There is no emphasize on the social institutional aspect of science but some aspect of it was included (Kaya & Erduran, 2016). Hence, it is necessary to examine how much

science textbooks, which have an important role in transferring the content of the curriculum to students, include the RFN categories.

There are many studies conducted to examine science textbooks in terms of inclusion of NOS in different perspectives (Campanile *et al.*, 2015; Irez, 2009; Kampourakis, 2017; Lumpe & Beck, 1996). However, because RFN is a fresh framework, there are very limited studies that examine the portrayal of NOS in science textbooks based on RFN (BouJaoude *et al.*, 2017; McDonald, 2017; Yang *et al.*, 2020). Examining only Lebanese, Australian and Korean science textbooks with the basis of RFN indicates that there is still a gap in the literature to present the coverage of NOS in science textbooks used by different countries. Hence, this study contributes to literature by putting the situation about representation of NOS in which science textbooks used in Turkey.

In this study, RFN which provides coherent theoretical justification was used as a theoretical framework because it offers organizational scheme to bring together different features of NOS in a coherent manner. Erduran and Dagher (2014a) propounded that understanding scientific knowledge and scientific processes are not sufficient for understanding science adequately because understanding science in depth is about how we perceive what science is. They also claimed that science lessons should include the social aspects of science for students to provide better understanding on how scientific endeavor works and how social structures affect the development of scientific knowledge (Erduran & Dagher, 2014a). RFN defines science as an epistemic cognitive and social-organizational systems with a set of compounds such as “aims and values”, “scientific practices”, “methods and methodological rules”, “scientific knowledge”, “social certification and dissemination”, “professional activities”, “scientific ethos”, “social values”, “social organizations and interactions”, “political power structures” and “financial systems” (Erduran & Dagher, 2014a). Presenting these 11 categories which reveal the collective and holistic aspect of science to students in science education enables students to understand NOS adequately. These categories state several ideas about science that establish an interactive dynamic relationship with each other instead of focusing on exclusive and distinct features of science. (Dagher & Erduran, 2017). Hence, the science textbooks were examined by focusing on each category in this study.

In order for students to grow up as scientifically literate, they need to read and learn scientific issues from a critical perspective like scientists. At this point, students can benefit from readings in science textbooks (Ulerick, 1989). Teachers have a great role in students' use of textbooks for more meaningful learning. The role of the textbooks used by teachers in their classrooms and teachers' intended goal to integrate textbooks in teaching process also affect students' use of the textbooks. The perceptions of teachers on highlighting scientific processes, scientific products and the nature of science by using textbooks and benefitting from different textbooks in science classrooms affect the students' perception on understanding nature of science and their perception on science textbooks (Ulerick, 1989). There are some studies that examine the teachers' use of science textbooks in teaching (e.g., Banilower *et al.*, 2013; Chambliss & Calfee, 1998; Chiappetta *et al.*, 1991; McDonald, 2016; Stake & Easley, 1978; Weis, 2013) but they have not examined the teachers' perceptions on use of science textbooks to teach NOS. So, this study contributes to literature by examining teachers' perceptions of RFN and the role of the textbooks to teach NOS. This study also includes teachers' suggestions on how to integrate the categories of science that are missing in the science textbooks.

Most of the researchers argue that nature of science should be taught to students at an early age (Eshach & Fried, 2005; Lederman & O'Malley, 1990). Many studies examining the students' views or perceptions on understanding nature of science were conducted with middle school students because they have cognitive efficiency to understand nature of science (Demir & Akarsu, 2018; Khishfe, 2008; Lin & Chiu, 2004; Senler, 2015). Some of them which focused on middle school students showed that students do not understand NOS adequately or adopt naive understandings (Demir & Akarsu, 2018; Lederman & O'Malley, 1990; Ryan & Aikenhead, 1992). Hence, it is important to study on science textbooks which seen as one of the reasons underlying the insufficient understanding of students about nature of science (Abd-El-Khalick & Akerson, 2004; Bianchini & Colburn, 2000). Most of the studies conducted to examine the representation of NOS in science textbooks focused on high school (Abd-El-Khalick *et al.*, 2008; BouJaoude *et al.*, 2017; Campanile *et al.*, 2015; Irez, 2009). However, it is necessary to examine the inclusion of NOS in middle school science textbooks. Hence, this study was focused on representation of NOS in middle school science textbooks.

Besides, the categories of RFN are suitable for students of all grade levels to understand nature of science (Erduran & Dagher, 2014a). Erduran and Dagher (2014a) argued that each category of RFN should be taught in each grade level even if the details of the categories vary by grade levels. Therefore, it is important to examine the science textbooks used by each level of middle grade to see the general picture of representation of NOS in middle school textbooks.

Also, this study offers some recommendations to book publishers and authors. Since the 2003-2004 academic year, textbooks are distributed to students free of charge by the Ministry of National Education (MoNE) in Turkey (Talim ve Terbiye Kurumu Başkanlığı [TTKB], 2019). Textbooks that must be taught in middle schools under the Ministry of National Education are prepared by both public and private sectors. The prepared textbooks are submitted to the Board of Education and Discipline for examination and evaluation (TTKB, 2019). The textbooks are evaluated according to the criteria of curriculum serving to reach explicit and implicit goals, supporting students to learn by themselves and guiding the teacher in the teaching processes taking place in the classroom environment (TTKB, 2019). In this context, this study presents some results on how nature of science was reflected in some examined science textbooks. According to the results and suggestions of this study, publishers are be able to pay attention to coverage of NOS in science textbooks in preparation and revision process of textbooks.

Lastly, the keywords that were generated during the content analysis can be used in other contexts. In other words, the representation of NOS can be examined in different textbooks by looking at whether the keywords and codes created in this study are existed in other textbooks.

1.4. Operational Definitions of the Key Terms

This subsection includes operational definitions of some key terms used in this study.

- *Nature of Science (NOS)*: The nature of science is defined as a fertile area that explains what science is, how science works, how scientists work collaboratively in a social group and how society directs and affects scientific enterprise (McComas *et al.*, 1998). In this study, the

term of NOS was used to describe science as a cognitive, epistemic and social institutional systems (Erduran & Dagher, 2014a).

- *Reconceptualized Family Resemblance Approach to Nature of Science (RFN)*: It is an expanded version of Irzik and Nola's (2011; 2014) FRA to NOS that defines science as a cognitive, epistemic and social-institutional system with a number of categories and represents NOS holistically in science education (Erduran & Dagher, 2014a; Kaya & Erduran, 2016).
- *RFN Perception*: This term operationally defined for this study as individuals own ideas and views on RFN categories.
- *Aims and Values of Science (AV)*: "The key cognitive and epistemic objectives of science, such as accuracy, empirical adequacy and objectivity" (Erduran & Dagher, 2014a; Kaya & Erduran, 2016, p.1123).
- *Scientific Practices (SP)*: "The set of epistemic and cognitive practices that lead to scientific knowledge through social certification" (Erduran & Dagher, 2014a; Kaya & Erduran, 2016, p.1123).
- *Methods and Methodological Rules of Science (M)*: "The manipulative as well as non-manipulative techniques that underpin scientific investigations" (Erduran & Dagher, 2014a; Kaya & Erduran, 2016, p.1123).
- *Scientific Knowledge (SK)*: "Theories, laws, and explanations that underpin the outcomes of the scientific inquiry" (Erduran & Dagher, 2014a; Kaya & Erduran, 2016, p.1123).
- *Social Certification And Dissemination (SCD)*: "The social mechanisms through which scientists review, evaluate, and validate scientific knowledge for instance through peer review systems of journals" (Erduran & Dagher, 2014a; Kaya & Erduran, 2016, p.1123).
- *Scientific Ethos (SE)*: "The norms that scientists employ in their work as well as in interaction with colleagues" (Erduran & Dagher, 2014a; Kaya & Erduran, 2016, p.1123).

- *Social Values (SV)*: “Values such as freedom, respect for the environment, and social utility” (Erduran & Dagher, 2014a; Kaya & Erduran, 2016, p.1123).
- *Professional Activities (PA)*: “How scientists engage in professional settings such as attending conferences and doing publication reviews” (Erduran & Dagher, 2014a; Kaya & Erduran, 2016, p.1123).
- *Social Organizations and Interactions (SOI)*: “How science is arranged in institutional settings such as universities and research institutes” (Erduran & Dagher, 2014a; Kaya & Erduran, 2016, p.1123).
- *Financial Systems (FS)*: “The underlying financial dimensions of science including the funding mechanisms” (Erduran & Dagher, 2014a; Kaya & Erduran, 2016, p.1123).
- *Political Power Structures (PPS)*: “The dynamics of power that exist between scientists and within science cultures” (Erduran & Dagher, 2014a; Kaya & Erduran, 2016, p.1123).
- *Representation of NOS*: This term operationally defined for this study as inclusion of NOS categories in a particular way in science textbooks.
- *Content Analysis*: “Content analysis is a research technique for making replicable and valid inferences from texts to the contexts of their use” (Krippendorff, 2004, p. 18). In this study, the content analysis operationally defined as analyzing how content, figures, questions and visuals in science textbooks represent NOS.

2. LITERATURE REVIEW

This chapter includes theoretical background of this study and related studies. In the first section the nature of science (NOS) in science education was explained from past to present and some different frameworks of NOS were defined. In the second section, Reconceptualized Family Resemblance Approach to NOS (RFN) were explained detailly. Then, in the third section, RFN categories such as “aims and values”, “scientific practices”, “methods and methodological rules”, scientific knowledge”, and “social institutional aspects” were included with the visualizations. Fourth section includes the studies conducted with the basis of RFN whereas the fifth section contains different studies that shows the importance of science textbooks in science instruction. Just after this section, the empirical studies conducted to examine the representation of NOS in different science textbooks were listed relationally. Lastly, all literature review sections were summarized.

2.1. Nature of Science in Science Education

In the last century, the nature of science has become the focus of science education. Development of science has affected the conception of NOS. Hence, different scientific communities have tried to define NOS, but they did not reach an agreement on the definition of NOS (American Association for the Advancement of Science [AAAS], 1990; Central Association for Science and Mathematics Teachers, 1907; Klopfer & Watson, 1957). Although there was no consensus on the definition of NOS it was defined as the epistemology of science, the way of knowing, or the system of values and beliefs that have an effect on the development of scientific knowledge in general (Abd-El-Khalick & Lederman, 2000a; Lederman, 1992). There are still some disagreements about how philosophers, historians and science educators define NOS (Alters, 1997; Smith *et al.*, 1997). Understanding of nature of science is an important step in educating students as scientifically literate. For this reason, studies have been carried out since 1900s on how teachers and students think and understand the nature of science. Not only the understanding of scientific knowledge, but also understanding of scientific inquiry has been a subject emphasized in science education (National Research Council [NRC], 1996; Lederman, 2007).

Scientific literacy has become an educational goal that has been emphasized in science education since 1970 and aimed to generate students who use scientific knowledge to make decisions on social, personal and scientific issues, and understand how science works (AAAS, 1990; NRC, 1996). In order to provide scientific literacy, understanding of nature of science and the understanding of scientific literacy seems essential in science education (Lederman & Lederman, 2012). In that point, it is important to distinguish the notion of nature of science from scientific inquiry which is the methods and activities facilitated the growth of scientific knowledge and the nature of scientific knowledge which instructional outcomes derived from scientific inquiry (Lederman & Lederman, 2012; NRC, 1996; Schwartz *et al.*, 2004).

According to the Abd-El-Khalick *et al.* (1998) it is very difficult to teach abstract concepts to students even if understanding of nature of science seem as an essential to generate scientifically literate students. In that point, Abd-El-Khalick *et al.* (1998) proposed some tenets that are suitable for each grade level to teach NOS in science classrooms. Recent history, Chang *et al.* (2010) reviewed the literature to see the common statements of NOS in the studies conducted between 1990 and 2007. Seven common statements were mentioned frequently in those studies such as “the tentative nature of scientific knowledge”, “observation, inference, and theoretical entities in science”, “the theory-laden nature of scientific knowledge”, “the creative and imaginative nature of scientific knowledge”, “the social and cultural embeddedness of scientific knowledge”, “scientific theories and laws”, and “myth of the scientific method”. Those seven tenets of consensus view were explained by Lederman *et al.* (2002) and provided basis for studies on NOS as follows:

(i) *The tentative nature of scientific knowledge*: Scientific knowledge, although reliable and durable, is never absolute or certain. This knowledge, including facts, theories, and laws, is subject to change.

(ii) *Observation, inference, and theoretical entities in science*: Observations are descriptive statements about natural phenomena that are directly accessible to the senses (or extensions of the senses). By contrast, inferences are statements about phenomena that are not directly accessible to the senses.

(iii) *The theory-laden nature of scientific knowledge*: The development of scientific knowledge is based on theory. Scientists theoretical and disciplinary commitments, beliefs, prior knowledge, training, experiences, and expectations actually influence their work.

(iv) *The creative and imaginative nature of scientific knowledge*: Science is empirical. Nonetheless, generating scientific knowledge also involves human imagination and creativity.

(v) *The social and cultural embeddedness of scientific knowledge*: Science as a human enterprise is practiced in the context of a larger culture and its practitioners are the product of that culture.

(vi) *Scientific theories and laws*: Scientific theories are well-established, highly substantiated, internally consistent systems of explanations. Laws are descriptive statements of relationships among observable phenomena. Theories and laws are different kinds of knowledge and one does not become the other.

(vii) *Myth of the scientific method*: The myth of the scientific method is regularly manifested in the belief that there is a recipe-like stepwise procedure that all scientists follow when they do science. This notion was explicitly debunked” (Lederman *et al.*, 2002, pp. 500–502).

Consensus view framework has been studied by many researchers in many years (Abd-El-Khalick & Lederman, 2000b; Akerson & Donnelly, 2008; Lederman *et al.*, 2002; McComas, 1998). Most of the researchers have developed their studies with regard to consensus view but some of them also have added other descriptors on consensus view to assess understanding of NOS or examine the representation of NOS in textbooks (McComas *et al.*, 1998; Osborne *et al.*, 2003; Smith & Scharmann, 1999).

Although consensus view has been the basis of the studies on nature of science for years, this understanding has been criticized by many researchers (Duschl & Grandy, 2011; Erduran & Dagher, 2014a; Yacoubian, 2012). As a result of the criticisms, different frameworks on nature of science have emerged such as “Whole Science” by Allchin (2011), “Features of Science (FOS)” by Matthews (2012), “Family Resemblance Approach to Nature of Science (FRA to NOS)” by Irzik and Nola (2011; 2014). Then, “Reconceptualized Family Resemblance Approach to NOS (RFN)” was proposed by Erduran and Dagher (2014a) and named by Kaya and Erduran (2016).

Allchin (2011) proposed an alternative framework to consensus view called as “Whole Science”. He criticized the consensus view by reshaping the present NOS characterizations to whole science. Allchin (2011) explained his framework as “reframing current NOS characterizations from selective lists of tenets to the multiple dimensions shaping reliability in scientific practice, from the experimental to the social—namely, to Whole Science” (p. 518). Although he had a consensus on importance of teaching some tenets of consensus view in science education, he reframed NOS characterizations by emphasizing some new compounds that are absent in consensus view such as “the role of funding”, “motivations”, “peer review”, “cognitive biases”, “fraud”, and “validation of new methods” (Allchin, 2011, p.524).

Allchin (2011) has criticized the consensus view because the tenets seem declarative rather than functional to integrate them into students’ lives. Also, Allchin (2011) needed to propose new framework called whole science because consensus view had a limited reference on personal and social decision making. Allchin (2011) thinks that the tenets of consensus view is limited to adequately explain the nature of science. In order to understand the nature of science in a clear way, he expressed that the range of dimensions should be taken into account about how reliability is provided while scientific knowledge is generated and how it is protected while transferring from one place to another (Allchin, 2011). According to Allchin (2011), the dimensions of science include how science works, and sometimes how and why it doesn't work. The framework emphasized the equilibrium between the fundamentals of reliability and the boundary of science to understand the nature of science adequately (Allchin, 2011).

Matthew (2012) is another researcher who proposed an alternative approach to consensus view called “Features of Science “(FOS). Matthew (2012) defines the science as a “historically embedded truth-seeking enterprise that has many features: cognitive, social, commercial, cultural, political, structural, ethical, psychological” (p. 4). According to him consensus view is so superficial to teach NOS in science classrooms, so some purification and treatment are necessary to improve some tenets philosophically and historically.

Matthew (2012) also criticized that consensus view gives an importance on scientific knowledge rather than process, institutions and cultural context that facilitate development

of scientific knowledge. Matthew (2012) has argued that the seven tenets of consensus view seem as different features of science (FOS) rather than parts of nature of science, so he added some new items on the NOS tenets listed by consensus view such as “experimentation”, “idealization”, “models”, “values and socio-scientific issues”, “mathematization”, “technology”, “explanation”, “worldviews and religion”, “theory choice and rationality”, “feminism”, “realism and constructivism”. He (2012) called those items as a feature of science (FOS) to pay attention on changeable characteristics of those items in different context.

Although the studies on nature of science are still conducted based on consensus view, some philosophers and researchers of science education are proposing new frameworks that criticize the consensus view (Irzik & Nola, 2011; 2014; Erduran & Dagher, 2014a). Irzik and Nola (2011; 2014) proposed an alternative framework which was originally formed by Wittgenstein (1958). “Family Resemblance Approach to Nature of Science (FRA to NOS)” is an alternative framework which remarks the similarities and differences among the branches and disciplines of science (Irzik & Nola, 2011; 2014).

According to Irzik and Nola (2011) there are different features of science which are shared by different science disciplines even most of them are common in each discipline. Although the authors have an agreement on list of the consensus view, they believed that consensus view has some weaknesses that do not include all aspects of science and do not show the differences and similarities among the disciplines of science. Irzik and Nola (2011) listed 3 weaknesses of consensus view to propose new framework which addressed those shortcomings. The first deficiency of consensus view mentioned by Irzik and Nola (2011) is that there are no tenets related to aims of science and diversity of methodological rules used in scientific investigations. Secondly, the authors stated that although some different branches of science such as chemistry and astronomy have different features the consensus view does not mention those differences in specified tenets. Lastly, the tenets included in consensus view are not comprehensive to teach NOS in a sophisticated way.

Irzik and Nola (2011) described the science by emphasizing some categories such as “activities”, “aims and values”, “methodology and methodological rules”, and “products”. By using those categories, they also highlighted that some science disciplines resemble

another in some characteristics but not all. For example, while observation which is kind of activity is common in almost all disciplines of science, observation practices may differ from discipline to discipline. In other words, a scientist who is in astronomy discipline can have some observation skills such as using a telescope to observe celestial bodies whereas a scientist who examines fossils should have different observational abilities to recognize the rocks that s/he collected instead of using the same observational skills. Briefly, there are different activities which are used by some disciplines, but they can differ each other in some points. So, FRA to NOS which criticizes the shortcomings of consensus view emphasizes the need of understanding the different features of the science disciplines as well as the common features of science.

Then, Irzik and Nola (2014) defined the science as a cognitive-epistemic and social institutional system in their later work. The authors changed the names of some categories mentioned in their previous study from activities to process of inquiry and from products to scientific knowledge. Also, they added new categories such as “professional activities”, “the system of knowledge certification and dissemination”, “scientific ethos” and finally “social values” as a social institutional aspect of science. Besides, Irzik and Nola (2014) emphasized the importance of teaching those categories to understand nature of science.

Another framework which criticizes the consensus view in terms of different aspects of science was proposed by Erduran and Dagher (2014a) who expanded and integrated Irzik and Nola’s FRA to NOS (2011; 2014) in science education. Then, Kaya and Erduran (2016) named the Erduran and Dagher’s version of FRA to NOS as “Reconceptualized Family Resemblance Approach to Nature of Science (RFN)”. In the following subsection, RFN was explained in a detail way because it is a theoretical framework of this study.

2.2. Reconceptualized Family Resemblance Approach to Nature of Science (RFN)

Erduran and Dagher (2014a) proposed a new approach based on philosophical perspective that gives an importance on analyzing and justifying science to understand nature of science. Erduran and Dagher (2014a) extended Irzik and Nola’s FRA to NOS (2011; 2014) by changing some names of the categories, forming new categories, creating

some visualization for each category to be used as a pedagogical tool and referring some applications of FRA to NOS in science education.

Erduran and Dagher's version of FRA to NOS has mentioned differently such as "Expanded Family Resemblance Approach to NOS" or "Family Resemblance Approach" in some studies (BouJaoude *et al.*, 2017; Dagher & Erduran, 2016; Erduran & Dagher, 2014b; Yeh *et al.*, 2019). Then, Kaya and Erduran (2016) formed a new terminology called "Reconceptualized Family Resemblance Approach to NOS" to refer Erduran and Dagher's (2014a) expanded version of FRA to NOS. Kaya and Erduran (2016) explained the reason for renaming the framework as "making this distinction is rooted in the need to clarify the various accounts of the family resemblance idea" (p. 1115). The term of RFN was used in this study to refer Erduran and Dagher's approach (2014a) which includes set of categories serving teaching and learning of NOS with pedagogical aims.

Erduran and Dagher (2014a) have tried to find an answer about which aspects of science should be integrated in science education because school science generally focuses on narrow, simple and inconsistent account of nature of science rather than emphasizing cognitive, epistemic and social institutional dimension of science in a holistic way. The adaptation of a more systematic and inclusive approach called FRA to NOS to characterize a field of science stated that FRA offers features that are common in all disciplines of science in broad categories, and also some features of science may differ from disciplines (Erduran & Dagher, 2014a). For example, data collection is commonly used practice in most of the field of science but their way to collect data can differ from each other (Irzik & Nola, 2014).

Irzik and Nola (2011) created some categories to refer science as a cognitive and epistemic system. They used "activities" term to mention in their initial work (Irzik & Nola, 2011) then they renamed this category as "scientific processes" (Irzik & Nola, 2014). Erduran and Dagher (2014a) approbated to use "scientific practices" term instead of using "activities" and "scientific processes" which are the similar terms point out some aspects such as experimentation and observation. They emphasized the epistemic and social institutional compounds of science are included in scientific practices, so it is not appropriate to use activities or process terms to refer the category related to epistemic, cognitive and social aspect of science (Erduran & Dagher, 2014a).

Another revise made by Erduran and Dagher (2014a) is about the number of the categories. Irzik and Nola (2011) formed 4 categories such as “activities”, “aims and values”, “methodologies and methodological rules”, and “products” in their initial work whereas they renamed and added new categories to refer social institutional aspects of science (Irzik & Nola, 2014). Erduran and Dagher (2014a) expanded the FRA to NOS by adding 3 different categories such as “social organizations and interactions”, “financial systems” and “political power structures” as a social-institutional aspect of science on Irzik and Nola’s (2014) limited social-institutional categories such as “professional activities”, “the scientific ethos”, “the social certification and dissemination of scientific knowledge” and “social values of science”.

Erduran and Dagher (2014a) also formed visualization called “FRE Wheel” presented in Figure 2.1 which shows the relations among cognitive, epistemic and social-institutional aspects of science and new generated categories to the Irzik and Nola’s (2014) version to represent “science as a holistic, dynamic, interactive and comprehensive system” (Erduran & Dagher, 2014a, p.29). The FRA wheel can be used as a pedagogical tool in science classrooms to teach and learn nature of science holistically. Phillips and colleagues stated the importance of visualization with following statement “visualizing objects assist in explaining, developing, and learning concepts in the field of science” (Phillips *et al.*, 2010, p. 63).

RFN is a novel framework which offers visual tools to teach and learn nature of science in holistic way because consensus view (Abd-El-Khalick & Lederman, 2000a) or other alternative frameworks (Allchin, 2011; Duschl & Grandy, 2011; Irzik & Nola, 2014; Matthews, 2012) have not generated any visualization to present the epistemic, cognitive and social institutional dimension of science. Also, RFN emphasizes the vertical and horizontal articulation of NOS ideas throughout the schooling years because it is important to consider the articulation of NOS for providing students to learn each aspect of NOS in each grade level across different science topics (Erduran & Dagher, 2014a). Vertical articulation of the NOS concepts is important to improve coherence throughout the years and the horizontal articulation is important to improve integration between the NOS subjects. Hence, RFN aims to teach the NOS ideas by reinforcing in a developmentally appropriate

manner from kindergarten to high school for students to acquire more sophisticated NOS understanding.

FRE wheel was formed by the interlacing of three circles. In the innermost circle, there are categories of “aims and values”, “scientific practices”, “methods and methodological tools” and “scientific knowledge” which are the epistemic and cognitive aspects of science. In the outer circle, there are 4 categories that express the social-institutional aspects of science such as “scientific ethos”, “professional activities”, “social values” and “social certification and dissemination”.



Figure 2. 1. FRA Wheel.

Source: [Erduran & Dagher, 2014a, p.28]

Finally, there are 3 categories added by Erduran and Dagher (2014a) in the most outer circle such as “social organizations and interactions”, “financial systems” and “political power structures” to Irzik and Nola’s (2014) version. FRA wheel shows that each category affects each other, and science cannot be considered separate from the social context. Erduran and Dagher (2014a) developed “Generative Images of Science” (GIS) for each category of RFN to be used as a pedagogical tool to teach NOS. Besides, the authors (2014a) emphasized the generative features of the formed visuals to be used in different context and adapted by other researchers based on the purpose of their studies.

The following section includes the RFN categories which are “aims and values of science”, “scientific practices”, “methods and methodological rules”, “scientific knowledge”, “social certification and dissemination”, scientific ethos”, “social values”, “professional activities”, “social organizations and interactions”, “political power structures” and “financial systems” and generative images developed for some categories by Erduran and Dagher (2014a).

2.3. RFN Categories

Erduran and Dagher (2014a) expanded the Irzik and Nola’s framework by adding new categories on current compounds of FRA to NOS. This section includes epistemic and cognitive categories which are “aims and values (AV)”, “scientific practices (SP)”, “methods and methodological rules (M)” and “scientific knowledge (SK)”, social-institutional categories of science which are “professional activities (PA)”, “scientific ethos (SE)”, “social values (SV)”, social certification and dissemination (SCD)” and new added categories which are “social organizations and interactions (SOI)”, “political power structures (PPS)” and “financial systems (FS)”. Also, this section includes some visualizations for each category developed by Erduran and Dagher (2014a) to show the relationship between the compounds of science and to use as a pedagogical tool for teaching and learning NOS.

2.3.1. Aims and Values

Reconceptualized Family Resemblance Approach to NOS (RFN) includes aims and values category to refer the cognitive and epistemic aspects of science. Some questions should be offered for teaching and learning aims and values of science. Those questions can be listed as: “What are the aims and values of science?”, “How do values of science function?”, “What values come into play when scientists choose between theories?” (Erduran & Dagher, 2014a, p. 41).

Some aims and values of science have mentioned by some philosophers and educators such as “consistency”, “simplicity”, and “fruitfulness” by Kuhn (1977), “closeness to truth” by Popper (1963), “empirical adequacy” by van Fraassen (1980), “ontological

heterogeneity” and “complexity” by Longino (1977), “respect for rational argument” and “commitment to gain objective knowledge” by Carrier (2013).

Allchin (1999) tried to reveal the difference of cultural values which are related to work of scientists and epistemic values which direct the methods of science. In spite of that, Irzik and Nola (2014) defined the aims and values of science with the basis of science as a cognitive and epistemic systems. Epistemic and cultural values function together to generate scientific knowledge so they cannot be separated from each other. Values have an important role on science because diversity of values contributes to development of robust knowledge and affect theory choice before conducting the scientific investigation (Allchin, 1999; Laudan, 1984; Longino, 1995). Also, values direct the scientist to choose appropriate methodological rules for their work and influence how scientists are in interaction with the environment while conducting the investigations (Erduran & Dagher, 2014a). Irzik and Nola (2011) stated that aims and values of science cannot be differentiated because they might have similar functions. Hence, Erduran and Dagher (2014a) created a visualization which shows the relations between epistemic, cognitive and social aims and values of science presented in Figure 2.2.

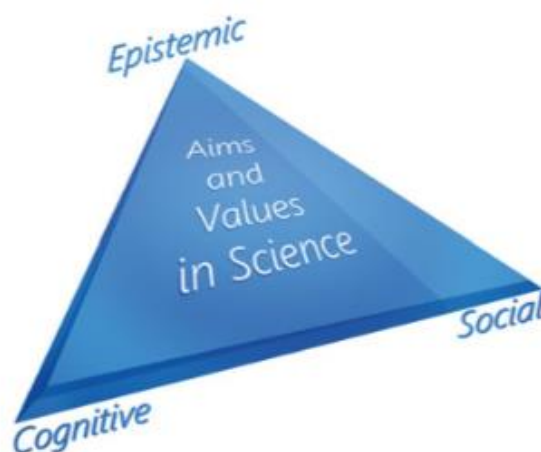


Figure 2. 2. Epistemic, Cognitive And Social Aims and Values in Science.

Source: [Erduran & Dagher, 2014a, p.49]

Erduran and Dagher (2014a) categorized the aims and values of science under epistemic, cognitive and social system to represent both their boundaries and connections. Erduran and Dagher (2014a) put aims and values in corners of triangle which shows that the

aims and values of science have not differentiated from each other at first glance because the boundaries of epistemic, cognitive and social aims and values in science are both blurry and continuous. Science does not work on moral and ethical issues. Therefore, while Erduran and Dagher (2014a) were developing a tool that demonstrates the aims and values of science, they did not place ethical and moral values especially in this visual. However, scientists should follow some ethical and moral rules during their studies (Erduran & Dagher, 2014a).

Erduran and Dagher (2014a) also mentioned some epistemic and cognitive aims and values which are “objectivity”, “novelty”, “accuracy”, “empirical adequacy”, “critical examination”, “addressing anomalies and counter instances” and “taking challenges seriously” as well social aims and values such as “addressing human needs”, “decentralizing power”, “honesty and equality of intellectual authority” by supporting each aim and values with the educational application presented in Table 2.1.

This table also includes some educational applications for each mentioned aims and values. For example, the students seek neutrality and avoid bias during their studies in science classrooms to fulfill novelty aim or they give some reasons to justify their claims to address critical examination which is the epistemic and cognitive aims and value of science. The table also shows how social values of science can be applied in educational settings. For example, the students pay regard the equality of intellectual authority which is the social value of science by respecting all ideas if presented with evidence.

Erduran and Dagher (2014a) like other researchers such as Irzik and Nola (2011) and Allchin (1999) emphasized that it is important to teach the aims and values of science in science lessons. Students are expected to know that scientific values guide scientific knowledge and scientific practices. It is also necessary to teach that aims and values affect a research method or how scientific knowledge is transmitted. Besides, the instructional methods with rich content and practices should be provided students to adopt epistemic values of science (Erduran & Dagher, 2014a).

Table 2. 1. Application of epistemic-cognitive and social aims and values of science in science education.

Source: [Erduran & Dagher, 2014a, p.52]

	Aim / value	Educational application
Epistemic-cognitive	Objectivity	Seeking neutrality and avoiding bias
	Novelty	Searching for new explanations
	Accuracy	Ensuring that explanations are accurate
	Empirical adequacy	Basing claims on sufficient, relevant and plausible data
	Critical examination	Giving reasons to justify claims
	Addressing anomalies and counter instances	Recognizing opposite ideas and responding to objections
	Taking challenges seriously	Taking opposition to own ideas seriously
Social value	Addressing human needs	Considering and respecting human needs
	Decentralizing power	Making sure nobody controls ideas to favor particular group biases
	Honesty	Being honest and acting honestly in all aspects of scientific activities
	Equality of intellectual authority	Respecting all ideas as long as they are evidence-based regardless of whose ideas they are

2.3.2. Scientific Practices

Scientific practices are important parts of the science education to engage students to perform epistemic goals of science (Aleixandre & Crujeiras, 2017). Instead of seeing science as a series of processes, the notion of practices moves towards emphasizing social interaction and discourse that play a role in the formation of scientific knowledge (Reiser *et al.*, 2012). Osborne (2014) argued that science education aims “explaining how we know what we know or why we believe what we do” (p. 580). Hence, the practices have roles to generate knowledge in science, understand the reason behind why we form knowledge, test, evaluate and develop it. (Aleixandre & Crujeiras, 2017). It shows that science includes set of scientific practices to build knowledge (Osborne, 2014).

Also, some of the science curricular documents such as National Research Council (NRC) and New Generation Science Standards (NGSS) emphasize the importance of scientific practices in teaching and learning science (National Research Council [NRC], 2012). NRC (2012) proposed 8 scientific practices that should be integrated in science education which are “asking questions and defining problems”, “developing and using models”, “planning and carrying out investigations”, “analyzing and interpreting data”, “using mathematics and computational thinking”, “constructing explanations and designing solutions”, “engaging in argument from evidence” and “obtaining, evaluating, and communicating information”

Erduran and Dagher (2014a) explored scientific practices and discuss about their implications in science education. Some curriculum reform documents mentioned above such NGSS and NRC have given more importance on notion of scientific practices, so it is important to define the scientific practices and their roles in science education (Erduran & Dagher, 2014a). Erduran and Dagher (2014a) have discoursed classification, observation and experimentation which are the important examples of the scientific practices on their reconceptualized framework. Erduran and Dagher (2014a) tried to exhibit activities, process of inquiry and scientific practices’ differences in their study because it is important to explain the rationale behind why they chosen notion of scientific practices in their framework.

Process of inquiry does not emphasize the epistemic features of the activities such as classification, observation and experimentation so science lessons do not mention how those activities facilitate development of scientific knowledge in a deep sense (Erduran & Dagher, 2014a). In other words, implementation of those activities in science classrooms is so procedural that shows how students carry out investigation and which types of materials they can use in particular activities (Chinn & Malhotra, 2002). Reconceptualized Family Resemblance Approach to NOS defines scientific practices as “the set of epistemic and cognitive practices that lead to scientific knowledge through social certification” (Kaya & Erduran, 2016, p.1123).

Erduran and Dagher (2014a) illustrated the difference of classification as an activity and scientific practice. The classification is usually seen as a sorting activity in school science. However, using classification as a sorting activity does not show students how this activity contributes to the development of scientific knowledge. Students complete the activity just by following the instructions provided to them and they cannot connect and understand the relationship between the given pieces (Erduran & Dagher, 2014a). It is necessary to teach students that scientists use the classification not only to sort things, but also to discover the characteristics of what they classify and to find their place in the classification based on their predictions. In other words, it is important to address the explanatory and predictive power of the classification in notion of scientific practices (Erduran & Dagher, 2014a). Science education requires students to be involved actively in scientific practices because “activities become the basis for learning about experiments, data and evidence, social discourse, models and tools, and mathematics, and for developing the ability to evaluate knowledge claims, conduct empirical investigations, and develop explanations” (Bybee, 2011, p. 38).

Erduran and Dagher (2014a) created a heuristic presented in Figure 2.3 to implement the model-based account of science discussed by some philosophers and cognitive scientists (e.g., Giere, 1991; Nersessian, 2003) in science education. The heuristic which was figured with analogy of benzene ring includes 6 carbons and pi bonds can be used as a pedagogical tool for teaching and learning scientific practices. Benzene Ring Heuristic (BRH) “brings together the disparate components of science” and “redefines the ‘discarded’ process skills aspects with the newer practices aspects” (Erduran & Dagher, 2014a, p. 80-81).

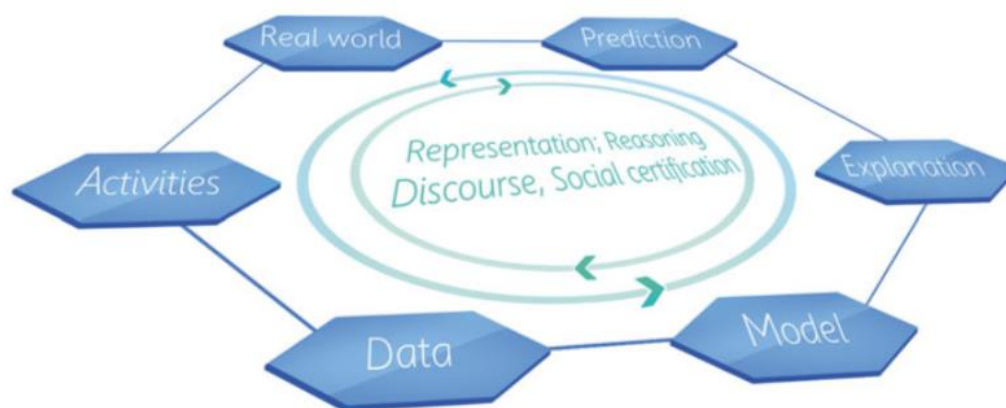


Figure 2. 3. Benzene Ring Heuristic of Scientific Practices.

Source: [Erduran & Dagher, 2014a, p.82]

Erduran and Dagher (2014a) represented scientific practices and their fluxional location with the analogy of 6 carbon atoms which flip around a circle. Social contexts were illustrated with pi electrons which move around the ring in benzene ring analogy. This heuristic indicates that each practice such as “real world”, “prediction”, “explanation”, “model”, “data” and “activities” are interrelating each other and they also affected by social dimensions such as “representation”, “reasoning”, “discourse” and “social certification” holistically to produce knowledge (Erduran & Dagher, 2014a). In other words, generated heuristic which can be used as a pedagogical tool exemplifies holistic approach that exhibits the interrelatedness of each practice to support development of scientific knowledge (Erduran & Dagher, 2014a).

2.3.3. Methods and Methodological Rules

The myth of the scientific method has been a highly discussed topic in science education. Most of the dictionaries and textbooks define the scientific method as general steps for conducting investigation. The Merriam-Webster online dictionary (n.d.) defines scientific method as “principles and procedures for the systematic pursuit of knowledge involving the recognition and formulation of a problem, the collection of data through observation and experiment, and the formulation and testing of hypotheses”. Although this definition can be seen as appropriate for young learners the necessity of constructing and testing hypothesis may cause students to have naive beliefs about scientific methods (Dagher & BouJaoude, 2005; Driver *et al.*, 1996). This may cause students to have the understanding

that the studies carried out without doing experiment and testing the hypothesis are less scientific (Dagher & BouJaoude, 2005).

Although scientists use different methods such as observing, collecting the data, comparing the results, measuring, testing, and constructing theories etc. there is no exact sequence of steps that is followed by scientists (Lederman *et al.*, 2002). Since, it is not correct to mention one scientific method that assures reaching unfailing knowledge (Bauer, 1994; Feyerabend, 1993) Hence, it is required to know that there are various scientific methods that can be used by scientist to conduct investigation and testing hypothesis is not required for all investigations (Erduran & Dagher, 2014a). Irzik and Nola (2014) emphasized the several methods and methodological rules that control the scientific activities.

Erduran and Dagher (2014a) are one of the researchers who tried to change focus from “the scientific method” to “scientific methods” to generate awareness of diversity of methodological rules and their mission on development of scientific knowledge. Philosophers and science education researchers have indicated that school science which teaches scientific method as step-by-step process and as one way to reach conclusion is very disputable to represent diversity of methodological choices to conduct investigation (Erduran & Dagher, 2014a). Woodcock also suggested to use “scientists’ toolbox” term rather than using “scientific method” to impart the diversity of tools that are used by scientist appropriately to reach conclusion (Woodcock, 2013).

School science is expected to teach that scientist use different types of methods without following fixed steps by considering the appropriateness of methods for their study. The science lessons should ease students to understand non-experimental method is as valuable as experimental one. In other words, students would understand scientists who study on astronomy do not conduct experiment by manipulating objects on space, but they still construct and test hypothesis without using experimental methods to obtain knowledge (Erduran & Dagher, 2014a).

Erduran and Dagher (2014a) also developed a gear visualization that shows the diversity of methods in particular disciplines of science and illustrate the relationship among those methods that contributes to notional diagram (see Figure 2.4). The authors (2014a)

also clarified that the size of the gears used in the depiction can be reshaped according to where the majority of the evidence came from during the scientific study.



Figure 2. 4. The ‘Gears’ Image of Scientific Methods and Their Relations.

Source: [Erduran & Dagher, 2014a, p.101]

The gears image can be used as a pedagogical tool to teach scientific methods in science classrooms such as hypothesis testing, non-hypothesis testing, manipulative and non-manipulative descriptions (Erduran & Dagher, 2014a). One aim of science education should be to inform students about how methodological choices have an effect on development of different types of scientific knowledge such as theory, law and model. Supporting the development of the sophisticated understanding of scientific methodology in science education requires educating students about the various questions that can be asked and the different ways to investigate them. Science education should encourage students to ask questions and find alternative ways to answer those questions. Instead of lecturing students what scientific methods are, students should be encouraged to decide which scientific methods can be used and to conduct investigation. It should also be taught in school science that the evidence obtained from different sources contributes to scientific knowledge.

2.3.4. Scientific Knowledge

Scientific knowledge is what scientists reached with scientific investigations. Erduran and Dagher (2014a) mentioned theories, laws, and models as a form of scientific

knowledge. Theory, law, and models (TLM) play a joint role in the emergence of scientific knowledge (Erduran & Dagher, 2014a). Theory, law, and model, which are types of scientific knowledge, emerge as products of the scientific enterprise with the contribution of scientific practices and scientific methods (Erduran & Dagher, 2014a; Giere, 1991). For example, atomic theory alone is not enough to explain the nature of matter, so molecular models and laws of elements work together to provide better understand the structure of matter. These three types of scientific knowledge work together to generate a new knowledge and explain the specific phenomena in the nature (Erduran & Dagher, 2014a). However, if there are results that do not support the existing theory, new explanations and theories can be replaced with previous theories, and this is called a paradigm shift (Kuhn, 1970).

Scientific laws and theories are two types of scientific knowledge that do not become transformed into each other. Laws are defined as “statements or descriptions of the relationships among observable phenomena” whereas theories are “inferred explanations for observable phenomena” (Lederman & Lederman, 2012, p. 337). Individuals have the idea that theories can turn into law when sufficient evidence is provided. However, scientific law is a type of scientific knowledge that does not have any advantage over theories. Both laws and theories are needed for the development of scientific knowledge (Lederman & Lederman, 2012).

Also, models represent concepts that cannot be directly observed or abstract. Erduran and Dagher (2014a) put the models in both scientific knowledge and scientific practices categories because models can be used as a tool for accessing scientific knowledge as well as being types of scientific knowledge. Besides, some researchers differentiated models as “part of a natural process used to construct an explanation of a phenomenon” and models as “representational tools for communicating a conceptual referent” (Romberg *et al.*, 2005, p.9).

Unfortunately, school science does not see theory, laws, and models beyond content knowledge, but school science has a role to teach students that TLM is a type of scientific knowledge which work together for development of scientific knowledge and contribute to explain a specific topic in a different field of science (Erduran & Dagher, 2014a). Erduran

and Dagher (2014a) generated a visualization that shows the working of the theories, laws and models together as a dynamic system to generate valid knowledge and to facilitate the comprehension of how universe function (see Figure 2.5). The visualization serves as a pedagogical tool that illustrate the coherence among theory, law and models to provide growth of scientific knowledge rather than depicting the scientific knowledge as an independent and disconnected piece of information (Erduran & Dagher, 2014a). In other words, TLM image can be used in science classrooms to illustrate the interrelated pieces of the scientific knowledge rather than discoursing the stand-alone pieces of scientific knowledge (Erduran & Dagher, 2014a).

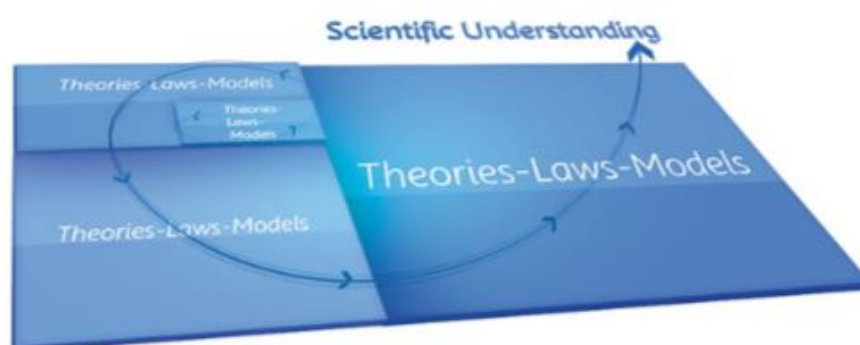


Figure 2. 5. Theory, Law and Model (TLM).

Source: [Erduran & Dagher, 2014a, p.115]

The planes of the heuristic include three forms of the scientific knowledge tends to replace by new sets of TLM which brings together unrelated compounds of knowledge to provide growth of knowledge (see Figure 2.5). Although theories, laws and models which are the forms of the scientific knowledge work together to produce knowledge in all science, the structure of the knowledge forms can be domain- specific (Duschl, 1990; Erduran & Dagher, 2014a). It means that function of theories and laws in different fields of the science such as biology, chemistry, physics, astronomy, botany etc. is related with the domain-specificity (Christie & Christie, 2003). Hence, TLM framework can be used in science lessons to teach specific structures of different branches of science.

Lastly, teaching the epistemic dimensions of TLM to students in school science helps students to understand in which conditions specific scientific knowledge can be considered

as acceptable, how theories, laws and models contribute to growth of scientific knowledge, and how it is used in different branches of science.

2.3.5. Science as a Social-Institutional System

Science is a social enterprise (Woodcock, 2014). Science cannot intrinsically be considered apart from the social and cultural system which include social values, particular activities, social communities and institutions (Erduran & Dagher, 2014a). Understanding of nature of science requires to comprehend that science is socially structured and validated (Driver *et al.*, 1994; McComas, 2006; Ziman, 1987). Although learning is an individual process, the development of knowledge requires individuals to discuss and think together in a social environment (McComas, 2006). Performing a scientific activity and reaching scientific knowledge as a result are not reduced to following the determined scientific steps. Questioning scientific ideas in social communities, passing those ideas through a filter and accepting them later reveal that the development of scientific knowledge is not focused only on the individual work (Woodcock, 2014).

The school science is expected to teach not only cognitive and epistemic aspects of science but also provide understanding of social systems which includes values and ethos scientists pursue (Erduran & Dagher, 2014a). The fact that science education includes only epistemic and cognitive aspects of science without comprise of social system restricts students' ideas about how scientific enterprise functions, what the relationship between social context and science and how the social system has an impact on the development of scientific knowledge. In other words, obtaining understanding of social features of science helps students to understand nature of science in a deep sense (Erduran & Dagher, 2014a).

Reconceptualized Family Resemblance Approach to NOS (RFN) includes four categories of “science as a social-institutional system” such as “professional activities”, “scientific ethos”, “social certification and dissemination of scientific knowledge” and “social values” referred in Irzik and Nola’s (2014) framework and new added categories such as “social organizations and interaction”, “political power structures” and “financial systems” by Erduran and Dagher (2014a). In the following part each category was explained in a detailed way.

Professional activities such as attending in conferences, seeking for funding resources, preparing proposals, publishing articles and peer-reviewing are as important element as producing knowledge in scientific enterprise (Irzik & Nola, 2014). In addition to conducting scientific studies using different methods, scientists apply for grants, supervise employees and prepare budgets (Woodcock, 2014). Even if school science does not give an importance on professional necessities of being scientists it requires to have some professional skills such as writing, presenting, reviewing, searching, publishing, evaluating of the findings in particular settings to complete the process of producing knowledge (Erduran & Dagher, 2014a). With the constructivist science teaching methods, the students are encouraged to present their findings of studies in the classrooms by discussing and reviewing of their peers' ideas to shape them (Erduran & Dagher, 2014a).

Scientific ethos is defined as norms and rules expected to be adopted by scientist during scientific investigations and interactions with their colleagues (Erduran & Dagher, 2014a; Irzik & Nola, 2014). There are some norms listed by some philosophers to be followed by scientists in scientific enterprise. Some norms seen as a proximate value that direct for reaching valid knowledge such as “universalism”, “organized skepticism”, “disinterestedness”, and “communalism” were derived from Merton’s study (Allchin, 1999; Barnes & Dolby, 1970). Besides, Resnik specified some norms that are essential for ethical consideration of scientific investigation such as “honesty, carefulness, objectivity, openness, freedom, credit, respect for intellectual property, respect for colleagues and student, respect for research subjects, competence, confidentiality, legality, stewardship of resources” (Resnik, 2005). Those norms are expected to be in school science because it provides understanding of which types of norms and rules should be followed to conduct investigation and produce knowledge.

Social certification and dissemination which is the compound of social institutional aspects of science contain sharing results of the studies at conferences, generating manuscripts of studies and publishing them in particular journals (Irzik & Nola, 2014; Kitcher, 2011). Communicating with other scientist in scientific communities enables studies to be reviewed and criticized by collaboration of others to facilitate producing knowledge (Woodcock, 2014). It is important to encourage students to understand the social

certification and dissemination process that scientists engage during the growth of knowledge in science lessons (Erduran & Dagher, 2014a).

Social values of science are other compounds of RFN framework which includes respect for environment, social utility and freedom (Erduran & Dagher, 2014a; Irzik & Nola, 2014). Scientists should conduct a scientific study that can be used for the benefit of society. Scientists should be environmentally conscious while conducting a scientific study and inform the community about any possible harm (Resnik, 2005). Scientists who are the part of the society have the responsibility of not conducting studies had a negative impact on the society and thinking about the social utility (Lakoff, 1980; Resnik, 2005; Shrader-Frechette, 1994). If scientists know that humans and animals have rights, they will avoid harming animals and humans during their studies (Jonas, 1969; LaFollette & Shanks, 1996). School science should provide students with the awareness that ideological and religious constraints hinder the conducting of scientific studies. In addition, students should understand that it is necessary to create an environment of freedom for scientists who are not restricted for any reason in order to increase the diversity of scientific studies and produce scientific knowledge (Erduran & Dagher, 2014a). Also, school science is expected to provide understanding that studies should be done in the public interest and that they should continue their scientific studies without harming the environment (Erduran & Dagher, 2014a).

Social organizations and interactions are the category of science as a social-institutional system which proposed by Erduran and Dagher (2014a) to extend the social context of science. This category includes the institutions such as universities, research centers and other socially organized places where scientist work with their colleagues to produce knowledge (Erduran & Dagher, 2014a). There are some hierarchy and division of labor that shows the social interactions among the team-members in institutions like CERN or NASA (Knorr-Cetina, 1999).

Political power structures category of RFN facilitates students to understand how science functions with the effects of politics of governments, race, economic, ideologies, cultural structures and interests of the governments (Erduran & Dagher, 2014a; Harding & Hintikka, 1983).

Financial systems are the last category of RFN which affects the science both positively and negatively. Funding is essential to carry out investigation so the scientist should find financial resources that fund for procuring the equipment's or paying the salary of the scientists in particular organizations (Erduran & Dagher, 2014a). Economic structures of the governments have an effect on process of scientific investigation (Erduran & Mugaloglu, 2013). Erduran and Dagher (2014a) also gave an importance on commercialization and commodification features of science. The generated knowledge such as technological output or specific procedure for scientific investigations is considered as a commodity that can be offered for a fee. In other words, the scientist can build their own enterprises to generate and put on sale their methods or products. Briefly, including the financial aspects of science in science lessons provides students to aware of economic dimension of science (Erduran & Dagher, 2014a).

In overall, the cognitive and epistemic aspects of science are not enough to get sophisticated understanding of nature of science and how science works. Hence, social institutional aspects of science should be integrated in science education holistically to capture the relations among the compounds of science and their impacts on growth of scientific knowledge.

RFN is a new framework that comprises of epistemic, cognitive, and social-institutional categories of science. Hence, it is necessary to work with different participant groups in different contexts to understand to what extent and how the Reconceptualized Family Resemblance Approach to NOS is integrated in science education. The next section includes some studies conducted in different contexts regarding RFN.

2.4. The Studies Conducted Based on RFN

Erduran and Dagher' FRA to NOS (2014a) which was named as RFN by Kaya and Erduran (2016) has been one of the research topics in science education since 2014. There are limited studies that examined the nature of science in science education about Reconceptualized Family Resemblance Approach to NOS (RFN). The studies were conducted to see the general pictures of NOS in curriculum documents, in-service and preservice teachers' views of NOS, middle school students' views of NOS and

representation of NOS in science textbooks. Some studies focused on each category of RFN while a few of them just examined the social-institutional categories. Erduran and Dagher's framework (2014a) was called differently in studies such as "Expanded Family Resemblance Approach to NOS", "FRA to NOS", and "Reconceptualized Family Resemblance Approach to NOS". However, all refer to the approach that Erduran and Dagher (2014a) adopted.

Firstly, there are 4 previous studies conducted to examine the inclusion of NOS based on Erduran and Dagher's version of FRA to NOS in science curriculum policy documents (Erduran & Dagher, 2014b; Kaya & Erduran, 2016; Park *et al.*, 2019; Yeh *et al.*, 2019). Erduran and Dagher (2014b) investigated the NOS representation in Irish draft science curriculum and Kaya and Erduran (2016) examined the existence of FRA to NOS components in two Turkish science curricula published in 2006 and 2013 and compared them with curricula from USA and Ireland. In recent years Yeh *et al.* (2019) examined two Taiwanese curriculum guidelines by adopting FRA to NOS as an analytical tool. Park *et al.* (2019) compared the two curriculum standards used in USA with regard to inclusion of epistemic STEM disciplines by using FRA to NOS as an analytical tool.

Secondly, there are also some studies conducted to see teachers' views on FRA to NOS. Saribas and Ceyhan (2015) conducted an auto-ethnographic study to examine the effect of using model called Benzene Ring Heuristic (BRH) proposed by Erduran & Dagher (2014a) on improvement of preservice science teachers' understanding of scientific practices. Likewise, Erduran *et al.* (2018) conducted a research about how scientific practices which are the compound of FRA to NOS has been incorporated into prospective teacher education program at the university in Turkey. Besides, Kaya *et al.* (2019) developed an experimental research in setting of a science education project at a university located in Turkey to see the effect of intervention which planned based on RFN on pre-service science teachers. In addition to those studies, Cullinane (2018) prepared workshop based on Erduran and Dagher's (2014a) NOS framework to improve Irish prospective teachers' NOS ideas in her doctoral dissertation. Kaya *et al.* (2018) also developed a research to investigate the perceptions and understandings of Irish prospective teachers about financial system of science which is the category of social-institutional aspects of science. Besides, Kelly and Erduran (2019) investigated the preservice science teachers' understanding of epistemic, cognitive, and social aims and values of science. Akgun and Kaya (2020) conducted a

research to examine the NOS understanding of university students from different departments based on Erduran and Dagher's (2014a) framework. Also, in similar way, Aksoz (2019) examined the teachers' perceptions and understanding of particular NOS aspects called aims and values and social-institutional aspects of science for offering suggestions to teach examined NOS aspects in her thesis. Besides, Erduran *et al.* (2020) compared the NOS perceptions of preservice science teachers from England and Turkey. One of the most recent studies was conducted to understand the difference between the science teachers' and non-science teachers' understanding of NOS (Azninda & Sunarti, 2021).

Thirdly, the researchers examined the middle school students' NOS understandings in their master thesis. Karabas (2017) investigated the impact of scientific practice-based instruction on 7th grade of students' perceptions of scientific practices. Besides, Akbayrak and Kaya (2020) carried out a study to detect 5th graders' understanding of social-institutional aspects of science which includes "professional activities", "scientific ethos", "social values", "social certification and dissemination", "social organizations and interactions", "political power structures" and "financial systems" in her thesis. Also, Cilekrenkli (2019) conducted a mixed design study based on RFN to examine the 5th graders' NOS understanding and perceptions.

Lastly, there are limited studies conducted to analyze the coverage of NOS in science textbooks based on RFN. BouJaoude *et al.* (2017) examined representation of NOS in Lebanese science textbooks used by 9th graders. Besides, McDonald (2017) presented the portrayal of NOS in genetic topics located in Australian junior secondary textbooks. In addition to these textbooks, the representation of NOS in Korean textbooks has been examined most recently (Park *et al.*, 2020; Yang *et al.*, 2020).

To see what extent science textbooks, contain the RFN categories, the textbooks used in different countries and by different student groups should be examined. This study examined Turkish science textbooks used in 4 different grade levels (5th, 6th, 7th and 8th). This provides a general picture for how NOS is represented in all science textbooks that students use from grade 5 to grade 8. Also, the studies conducted by BouJaoude *et al.* (2017) and McDonald (2017) did not include any teacher views on roles of science textbooks to teach NOS. Hence, this study also examined the science teachers' perceptions of RFN,

science teachers' perceptions on representation of NOS in science textbooks and science teachers' perceptions on using textbooks in addressing the NOS.

This study was designed upon studying science textbook. Because science textbooks are important tools that middle school science teachers use to educate students (Chiappetta *et al.*, 1993). In some science classrooms, textbooks can take the curriculum role and can be integrated into the course as the ultimate knowledge source (Stake & Easley, 1978). At this point, it is necessary to understand the role of science textbooks in science classrooms and how often they are used by science teachers. The next section includes studies that reveal the role of science textbooks in science instructions.

2.5. The Role of Science Textbooks in Science Instruction

Science teaching aims students to get knowledge of science and apply them in their daily lives. The teaching strategies should be varied to help students to learn better and to make them scientifically literate individuals who have the critical thinking, problem-solving competencies to solve daily life problems and discuss the scientific topics. The studies conducted in the last 30 years indicated that most of the students who are in primary school, elementary school, secondary school, high school or university level are struggling with some learning difficulties and have some misconceptions about some scientific concepts although the teachers try to use many different learning strategies. The misconceptions or inadequate explanations in textbooks may cause students not to understand the content and have misunderstandings (King, 2010).

The textbooks are prepared to provide a physical tool for both teachers and students that create a connection between teaching and learning.

The textbooks act as a bridge between the curriculum policies developed by the curriculum developers based on some philosophical, historical, and social foundations of countries and the instruction managed by the teachers (Chiappetta & Koballa 2002). The effect of textbooks on students' learning process is an inevitable fact because the textbooks can influence the student's learning directly or indirectly. Valverde *et al.* (2002) mentioned that "textbooks help define school subjects as students experience them. They represent school disciplines to students" (p. 1). Hence the students should interact with the textbooks closely.

Peacock and Cleghorn (2006) stated the importance of the textbooks by emphasizing the effects of the textbooks on students and instructions.

“Firstly, they are for telling, providing facts, explaining concepts, giving instructions. Secondly, they are for asking, prompting, inquiry, setting problems, requiring data analysis, predictions, analysis, or conclusions. Third, they are for coaching; mediating, revising, practice testing, working examples. Finally, they can be for motivating; getting children excited about something they might then experience first-hand” (Peacock & Cleghorn, 2006, p. 41).

Textbooks are a crucial tool to get knowledge, so it affects students to understand the scientific knowledge adequately (Kesidou & Roseman, 2002). If there is inadequate or inconsistent scientific knowledge in science textbooks it causes students to get some misconceptions (Devetak & Vogrinc, 2013). The studies showed that science textbooks are a very important source in secondary science education in many countries (Barba *et al.*, 1993; Kahveci, 2010; Roseman *et al.*, 2010). Most of the research indicate that teachers are benefitting from science textbooks for different purposes such as directing instruction, giving homework, sequence of learning and teaching methods, selecting the topic and their sequence (Chambliss & Calfee, 1998; Chiappetta *et al.*, 1991; Lumpe & Beck 1996; Martínez-Gracia *et al.*, 2006; Spiegel & Barufaldi, 1994; Stern & Roseman, 2004; Weiss *et al.*, 1989). Besides, there are some studies which examine the percentage of using textbooks in science lessons (Banilower *et al.*, 2013; McDonald, 2016; Weis, 2013).

McDonald (2016) conducted a research study with 486 teachers with the purpose of examining the usage of science textbooks in Australia. The quantitative data results showed that 87% of the participants are using current science textbooks in their classrooms, and 72% of the participants are satisfied with the textbooks currently used. However, 16% of participants are neutral, and 12% of them are unsatisfied with their textbooks. The similar findings found by Weis (2013) who examined textbook usage of 958 middle school teachers. The results showed that 80% of the participants practice on science textbooks. Comparable results were acquired from the government report (Council for Science and Technology, 2000) which indicated that 89% of high school teachers use science textbooks in their classrooms. Besides, the National Science Foundation (NSF) conducted a research with the 7752 science and mathematics teachers in the US to examine their textbook usage and results showed that most of the teachers benefit from science textbooks in their science lessons

(Banilower *et al.*, 2013). Earlier studies are consistent with the latest study results which showed that most of the teachers use science textbooks in their classrooms (Stake & Easley, 1978).

Although the science textbooks have a big impact on shaping science instructions, there are some studies showed the deficiencies of science textbooks. Chiappetta *et al.* (1993) found that the large quantity of information about science contents was presented superficially in textbooks. The other limitation of textbooks was detected by researchers is including the sheer amount of lower cognitive level questioning that does not promote students' critical thinking skills (Pizzini, 1992; Shepardson & Pizzini, 1991; Vasconcelos *et al.*, 2012). In addition, science textbook includes many misconceptions that cause students to get misunderstanding about science topics (Eyidoğan & Güneysu, 2002; Kook, 2003). Another deficiency of science textbook has to do with gender biases included in textbooks (Elgar, 2004; Walford, 1980). Lastly, many studies showed that science textbooks do not represent nature of science well and they may address the scientific facts implicitly instead of defining a dynamic process of development of knowledge (Abd-El-Khalick *et al.*, 2008; Chiappetta *et al.*, 1991; Gibbs & Lawson, 1992; Lumpe & Beck, 1996; McDonald, 2017).

In order to determine whether science textbooks used by teachers for many different purposes are quality textbooks, the main question regarding the content of the science textbook is: “does the textbook accurately present the nature of science within a relevant context for the student?” (Chiappetta *et al.*, 1993, p.788). The next section includes the studies conducted to examine the portrayal of NOS in science textbooks because previous studies mentioned above indicated that most of the teachers benefit from science textbooks in their classroom and textbooks are the crucial tools for students to learn scientific concepts (Kahveci, 2010; Laws *et al.*, 1990). In that point, examining in which degree science textbooks cover NOS is required to specify whether those textbooks are well qualified to teach NOS in science classrooms.

2.6. Portrayal of NOS in Science Textbooks

The science textbooks should comprise the nature of science with some activities to engage students to conduct an investigation, gather data, reach conclusion and include some

social aspects of science to show the relationship among science, technology, and society. The textbooks represent some goals of general science education such as inquiry skills, decision-making skills, and positive attitudes towards science. The textbooks are the crucial instructional sources that help teachers to plan their lessons and act as a bridge between national curricular standards and science instructions (Chiappetta & Koballa, 2002). Nature of science (NOS) which is an important part of scientific literacy has become the trend in textbook analysis which examines how textbooks portray the NOS (Abd-El-Khalick *et al.*, 2008; McComas, 2003; Williams, 2003).

Chiappetta *et al.* (1991) conducted a study to investigate the themes of scientific literacy such as science as a body of knowledge, science as a way of investigating, science as a way of thinking and the interaction among science, technology, and society in high school chemistry textbooks. The findings showed that science as a body of knowledge, science as a way of investigating was emphasized in most of the science textbooks whereas there is little attention on the interaction among science, technology, and society theme. The inadequate emphasis of science as a way of the thinking theme was found as an important result of the study. Several years later Chiappetta and his colleagues (1993) studied on inclusion of scientific literacy themes in middle school life science textbooks. The result of the research was consistent with their previous research (1991) which found more emphasizes on science as a body of knowledge and science as a way of investigating themes, but little attention on interaction of science, technology, and society theme.

Many researchers used the Chiappetta and his colleagues' scientific literacy approach to investigate science textbooks. Lumpe and Beck (1996), one of those researchers, examined the biology textbook according to the scientific literacy framework adopted by Chiappetta and his colleagues. As a result, it was found that the textbooks emphasized the science as a body of knowledge, and science as a way of investigating, similar to the results of the work of Chiappetta *et al.* (1993; 1991) it was found that there was very limited inclusion of on the interaction of science, technology, and society term in examined textbooks. Similar results were found in Wilkinson's study (1999) which examined 20 high school physics textbooks by considering inclusion of scientific literacy themes.

There are also some studies conducted to examine the textbooks in terms of scientific literacy themes in recent years. Phillips *et al.* (2015) examined 20 textbooks that are used in elementary schools from 1st to 5th grade in terms of 4 aspects of NOS. Most of the inclusion of NOS was detected in methods of the science section of each textbook. It was found that examined textbooks represented science as a way of investigating aspects than other aspects. The authors suggested that the interaction of science, technology, and social aspect should be integrated into the elementary textbooks. The result of this study is also in line with Lee's study (2014) which showed both textbooks gave more attention to the investigation and thinking process of a scientist rather than other aspects in USA and Korea high schools' science textbooks.

Abd-El-Khalick *et al.* (2008) were conducted a study to see the inclusion of NOS in 14 chemistry textbooks used in high schools and detect the changes that occurred on the inclusion of NOS in textbooks within past four decades. Abd-El-Khalick and his colleagues (2008) developed a scoring rubric that assesses the representation of NOS by considering explicit and implicit statements. They examined the textbooks with regard to 10 NOS aspects such as "tentative", "inferential", "creative", "empirical", "social dimensions of science", "theory-driven NOS", "scientific theories", "scientific laws", "and the social and cultural embeddedness of science", and "the myth of the scientific method". The results showed that the textbooks portrayed poorly NOS, and there are no big differences in the inclusion of NOS among the textbooks over the past four decades. These results are not in line with the aims of the national and international science education curricula which emphasize the importance of NOS (AAAS, 1990; NRC, 1996) and their statements about increasing emphasis on NOS and scientific literacy in science education. Lately, Abd-El-Khalick *et al.* (2017) enlarged their study to look at the inclusion of NOS in 34 high school biology and physics textbooks used in the US. The result of the study showed the underrated representation of NOS and the existence of naïve beliefs about NOS.

The other research which indicated a lack of explicit references to the nature of science in intermediate science trade books in the US was developed by Abd-El-Khalick (2002). Unlike the result of Abd-El-Khalick's study (2002) which found no references to NOS in examined books. Brunner and Abd-El-Khalick (2017) found that NOS was explicitly

referred to in 2 trade books. However, the other examined trade books did not include any informed reference to NOS (Brunner & Abd-El-Khalick, 2017).

After the study conducted by Abd-El-Khalick and his colleagues (2008), many researchers have used the framework developed by them to examine the representation of NOS in the science textbooks used in different countries. Irez (2009) is one of those researchers who conducted a research to examine the inclusion of NOS in Turkish biology textbooks used by 10th graders. Each textbook was analyzed with respect to 11 aspects of NOS. The results indicated that inferential and social NOS were neglected in most of the textbooks, and the myth of scientific knowledge was the poorly reflected aspect of science. Also, Li *et al.* (2018) analyzed 5 Chinese junior high school physics textbooks to disclose the representation of NOS. The results showed that there is no reference on subjective, scientific theory, or scientific laws aspects of NOS. Also, other categories were not treated well in textbooks. The result of the Irez (2009) and Li *et al.* (2018) were consistent with some studies (Wei *et al.*, 2013; Ramnarain & Chanetsa, 2016).

Likewise, Campanile *et al.* (2015) developed research to examine the representation of NOS and scientific inquiry in the Mendelian genetics chapters of biology textbooks used in the US and practiced on the International Baccalaureate Diploma Program (IB) in most countries. The results showed that most of the NOS aspects were represented implicitly. The result of this research is supported by El-Mehtar and Alameh's study (2017) which examined NOS representation in IB chemistry textbooks. Regardless, El-Mehtar and Alameh found that at least one aspect of NOS is included in each textbook, unlike the previous studies that did not refer to any aspects of NOS in the textbooks examined (Abd-El-Khalick *et al.*, 2008; Vesterinen *et al.*, 2013).

There are limited studies conducted to analyze the NOS representation in science textbooks by adapting Erduran and Dagher' (2014a) version of FRA to NOS as a theoretical framework (BouJaoude *et al.*, 2017; McDonald, 2017). Erduran and Dagher's (2014a) version of FRA to NOS was mentioned as "Expanded Family Resemblance Approach to NOS" in both studies.

BouJaoude *et al.* (2017) examined how 11 categories of FRA to NOS are presented in the Lebanese chemistry, life and earth science and physics textbooks used by 9th graders. The results showed that while the chemistry textbook referred to 4 categories, life and earth science textbooks include 5 categories of framework out of 11 categories. The categories which are AV, SP, SCD, PA, FS, PPS and SOI were not included in chemistry textbook and the categories which are SE, SCD, PA, FS, PPS and SOI were not included in life and earth science textbook. Unlike these results, the physics textbook was the only textbook that did not refer to any categories of the FRA to NOS.

In addition, McDonald (2017) analyzed the NOS representation in the genetics chapters of Australian secondary biology textbooks with regard to 11 NOS categories of expanded FRA to NOS. The result of this study was found consistent with previous studies conducted based on different perspectives (Abd-El-Khalick *et al.*, 2008; Campanile *et al.*, 2015; Ramnarain & Chanetsa, 2016; Wei *et al.*, 2013) and BouJaoude and his colleagues' study with the same framework called as FRA to NOS. Results indicated that there were only 3 NOS statements referred explicitly which in the scientific knowledge category of FRA to NOS. It also showed that there was no reference to the aims and values category in examined chapters and social-institutional aspects of science were found implicitly.

Textbooks in different contexts still need to be examined based on RFN even if there are studies that examined the Lebanese and Australian science textbooks. Although the books analyzed in 2 studies showed that NOS is not sufficiently emphasized and does not include many categories of science, an analysis of science textbooks used at different grade levels is needed. For this purpose, this study investigated the representation of NOS in Turkish science textbooks that were approved by the Ministry of National Education (MoNE) and were distributed to all middle school teachers and students to use in the science classrooms.

While examining the representation of NOS in science textbooks, many approaches have been adopted as a both theoretical and analytical frameworks, and different aspects of science have been examined by researchers. This study examined the representation of nature of science in Turkish science textbooks based on Reconceptualized Family

Resemblance Approach to NOS (RFN) because RFN offers organizational scheme to bring together different features of NOS in a coherent manner.

2.7. Summary of the Literature Review

In the first section of the literature review part nature of science in science education was explained. Although there is no agreement between the educators and philosophers about definition of NOS, they are agreed on the importance of teaching NOS to generate scientifically literate students (Abd-El-Khalick & Lederman, 2000b; National Research Council (NRC), 1996). Then, different perspectives towards NOS such as consensus view which includes seven tenets such as “the tentative nature of scientific knowledge”, “observation, inference, and theoretical entities in science”, “the theory-laden nature of scientific knowledge”, “the creative and imaginative nature of scientific knowledge”, “the social and cultural embeddedness of scientific knowledge”, “scientific theories and laws”, and “myth of the scientific method” were studied by most of the researchers in different contexts (Lederman *et al.*, 2002). Although consensus view has been the basis of the studies on nature of science for years, this understanding has been criticized by many researchers (Duschl & Grandy, 2011; Yacoubian, 2012). As a result of these criticisms, different frameworks about the nature of science have emerged such as “Whole Science” by Allchin (2011) “Features of Science (FOS)” by Matthews (2012), “Family Resemblance Approach to Nature of Science (FRA to NOS)” by Irzik and Nola (2011; 2014) and “Reconceptualized Family Resemblance Approach to NOS (RFN) proposed by Erduran and Dagher (2014a) and renamed by Kaya and Erduran (2016).

The second section includes Erduran and Dagher’s version of FRA to NOS which defines science as a cognitive, epistemic, and social-institutional system including different categories such as “aims and values”, “scientific practices”, “methods and methodological rules”, “scientific knowledge” and “social-institutional aspects of science”. Then, Kaya and Erduran (2016) used a new terminology called “Reconceptualized Family Resemblance Approach to NOS”. The FRA Wheel (Erduran & Dagher, 2014a) which is the heuristic that explains the connection among the compounds of science was included in this section.

In the third section, each compound of RFN such as “aims and values”, “scientific practices”, “methods and methodological rules”, “scientific knowledge”, “social certification and dissemination”, “professional activities”, “scientific ethos”, “social values”, “social organization and interactions”, “political power structures” and “financial systems” were explained detailly and RFN based studies were listed immediately after. It can be said that there are limited studies conducted by depending on Reconceptualized Family Resemblance Approach to NOS (RFN). Briefly, there are some studies for curriculum analysis (e.g., Erduran & Dagher, 2014b; Kaya & Erduran, 2016; Park *et al.*, 2019; Yeh *et al.*, 2019), textbook analysis (e.g., BouJaoude *et al.*, 2017; McDonald, 2017; Park *et al.*, 2020), in-service and preservice teachers’ understanding of NOS (e.g., Akgun & Kaya, 2020; Aksoz, 2018; Erduran *et al.*, 2018; Cullinane, 2018; Kaya *et al.*, 2019; Kelly & Erduran, 2019; Saribas & Ceyhan, 2015) and middle schoolers NOS understanding (e.g., Akbayrak & Kaya; Cilekrenkli, 2019; Karabas, 2017).

The fourth section indicated that the teachers use science textbooks in their classroom with different purposes such as giving homework, preparing lesson plans and specifying sequence of lessons (Chambliss & Calfee 1998; Chiappetta *et al.*, 1991; Lumpe & Beck 1996). The effect of textbooks on students' learning process is an inevitable fact because the textbooks can influence the student’s learning directly or indirectly (Valverde *et al.*, 2002). Hence, it is important to look at the in which degree NOS is included in science textbooks to discuss whether those textbooks are appropriate and enough to be used as a source to teach NOS to students.

The last section which includes different types of studies conducted to investigate the coverage of NOS showed that most of the textbooks did not represent NOS explicitly and adequately (Campanile *et al.*, 2015; Irez; 2009; Kampourakis, 2017). Briefly, there are very limited studies that examined the inclusion of NOS in science textbooks based on RFN (BouJaoude *et al.*, 2017; McDonald, 2017; Park *et al.*, 2020; Yang *et al.*, 2020). Hence, this study examined the inclusion of NOS in middle school Turkish science textbooks and teachers’ opinions about the usage of science textbooks to teach NOS with the basis of RFN.

3. METHODOLOGY

The methodological details of the study are covered in this chapter. the research design, data sources, sampling, data analysis, trustworthiness and ethical consideration of the study are listed following sections.

3.1. Research Design

The first part of the study includes analysis of representations of NOS in 5th, 6th, 7th, and 8th-grade Turkish science textbooks that were given to students by the Ministry of National Education (MoNE). The qualitative content analysis method was chosen to investigate representations of NOS in science textbooks with the basis of the Reconceptualized Family Resemblance Approach to Nature of Science (RFN) outlined by Erduran and Dagher (2014a).

Content analysis is a research method that is used to draw systematic and unbiased results from certain characters defined in the text. (Stone *et al.*, 1966). According to the Krippendorff (2004) “content analysis is a research technique for making replicable and valid inferences from texts to the contexts of their use” (p. 21). The qualitative content analysis method was selected as a research design of the study to analyze the content of texts and explain the themes emerged from the analysis. Content analysis can be designed with either quantitative or qualitative data. This selection is dependent on the aims of the study. The inductive approach is used when the categories are wanted to form through the data due to the lack of the former knowledge whereas the deductive content analysis is chosen based on the determined structure of analysis based on the previous studies (Kynga’s & Vanhanen 1999).

The deductive approach was followed in this study because the categories of the RFN were stated before (Erduran & Dagher, 2014a). This study aims to find the codes under each category to analyze the representation of the NOS in science textbooks. After determining the codes under each category, the example quotations were given to provide the reliability

of the given codes. The second part of the study was conducted to draw a conclusion about teachers' views on science textbooks after completing the first part of the study and to gain a deeper understanding about how teachers use national science textbooks in their lessons to teach the NOS and what are their suggestions for the inclusion of the RFN categories in science textbooks (Creswell, 2002). The thematic analysis which is a method to analyze the qualitative data were used to examine the common ideas of science teachers about science textbooks.

3.2. Data Sources

In this study, two different data sources were used to collect data. The textbooks were used to examine the representation of the NOS in 5th, 6th, 7th, and 8th-grade science textbooks. To investigate science teachers' views on NOS, science textbooks and their suggestions to include the RFN categories in science textbooks the interviews were conducted with science teachers.

3.2.1. Textbooks

Representations of NOS based on the RFN were examined in the four lower secondary textbooks which were approved by the Ministry of National Education (MoNE) and distributed free to all schools in Turkey. This study aims to determine to what extent the textbooks used in lower secondary schools contain the Nature of Science (NOS). To continue the study with this purpose, lower secondary school textbooks should be used as a data collection tool. Therefore, 5th, 6th, 7th, and 8th grade science textbooks including 223, 287, 256 and 292 pages respectively were used to collect data.

3.2.2. Teacher Interviews

The qualitative data were collected through interviews with participants to get deeper understanding about their views on NOS and science textbooks, and their suggestions for the inclusion of the RFN categories in science textbooks. The participants are 8 science teachers. The characteristics of the teachers were explained in the sampling section. The consent forms were given to science teachers before conducting the interview. The schedule

was arranged with science teachers who are confirmed to participate in the study to decide the interview date with interviewers.

The qualitative interview takes place when the researcher poses open-ended questions to the participants and the answers of the participants are recorded (Creswell, 2002). According to Fontana and Frey (2000), semi-structured interviews are the most useful and strong tools to understand the thinking of the individuals because the interviewer asks open-ended questions and only listens and records what the interviewee says without giving an opinion. The questions were prepared by the researcher for this study to examine science teachers' opinions about the NOS, science textbooks and their suggestions for inclusion the RFN in science textbooks. The researcher decided to use interviews instead of observation to get teachers' views because there is an opportunity to ask specific questions during the interviews to get more information about the issue. Besides, observation sometimes is not good tool to describe individual information in a detailed way whereas the interview provides to get more useful and detail answers from the interviewees (Creswell, 2002).

One-on-one interviews were decided to be conducted in this study because whatever the researcher asks, the participant answers that question so that all questions can be answered and recorded one by one. Face to face interviews conducted with the participants at different times. A quiet environment where participants feel in a safe was determined by consulting them. The aim of the study was explained to the participants verbally and they were be told that they can end the interview at any time without offering any reason. It was explained to the participants that the interviews were kept anonymous and confidential, audio recordings were not used anywhere. The interviews were audio-taped after getting permission from all participants. The researcher also took short notes during the interviews. Each interview took about 50-70 minutes.

There are 16 main open-ended questions and some of these questions are divided into sub-questions (see Appendix A and B). There are 3 categories such as Questions For NOS, Questions for Science Textbooks and Questions for Teachers' Suggestions in the interview protocol. The distribution of the questions is given in Table 3.1. The total number of questions is 37.

Table 3. 1. Distribution of interview questions.

	Main Questions	Sub-Questions	Total
Questions for NOS	8	10	18
Questions for Science Textbooks	6	0	6
Questions for Teachers' Suggestions	2	11	13
Total	16	21	37

The experts examined the interview questions to provide inter-rater reliability. Some incomprehensible questions were edited, and some new questions were added. The pilot study was done with two science teachers who did not participate in the study for reliability and validity issues. After analyzing the data gathered from these two participants, the questions were edited to provide better understanding of the questions.

3.2.3. NOS Questionnaire

“NOS Questionnaire” which is developed by Kaya, Erduran, Aksoz, and Akgun (2019) includes 70 questions representing “aims and values” (AV), “scientific practices” (SP), “methods and methodological rules” (M), “scientific knowledge” (SK), “social-institutional systems (SI) (see Appendix C). These categories are represented with 9, 15, 12, 14, 20 questions respectively. There are also 16 questions for educational application of RFN in science lessons. This questionnaire was used to measure participants’ understanding of “Reconceptualized Family Resemblance Approach to Nature of Science”. The questionnaire was designed as Likert scale including 5 options from ‘totally agree’ to ‘totally disagree’. The questionnaire includes 49 positive items and 21 negative items. The “totally agree”, ‘agree’, “not sure”, ‘disagree’, and “totally disagree” are scored as 5, 4, 3, 2, 1. The Cronbach alpha was calculated as 0.8 (Kaya *et al.*, 2019).

3.3. Sampling

In this section the sampling procedure is explained in detail. The science textbooks are the samples of the study for collecting data to display the representation of NOS in science textbooks. Also, the data were collected from the science teachers to gather their

opinions about science textbooks with respect to RFN. The sampling of textbooks and science teachers is explained below.

3.3.1. Sampling of Textbooks

The four different science textbooks are one of the samples of the study. These textbooks were selected purposively. The main criterion for selecting the textbooks is that they are the science textbooks and only one textbook was selected from each grade level in middle school which are 5th, 6th, 7th and 8th grades.

With the "Free Book Distribution Project in Primary Education" initiated by the Ministry of National Education in 2003, textbooks were given to students free of charge to provide equal opportunities in education. Within the scope of this project, an editorial board that was established within the Board of Education and Discipline examines the drafts of the textbooks sent to them, choose for 5 years to be used in schools, and the copyright of the textbooks were purchased (Bayrakçı, 2005). The free distribution of textbooks, which came into force in 2003, continues today for primary, secondary and high school levels.

Currently used textbooks are also published free of charge in the socially qualified educational electronic content network called "Education Information Network" (EIN) which was established by the Ministry of National Education in Turkey. Some of these textbooks were prepared by private publications, while others were prepared by MEB publishing. Multiple textbooks for some grade levels are approved by the Ministry of Education. Therefore, a different book belonging to the same grade level can be distributed to students for some years. However, all of these books include the same objectives and similar sequence of content. All teachers and students can access alternative textbooks selected for the same grade level freely through an EIN.

In the selection of the textbooks, it was paid attention that all textbooks which were selected for this study has been accepted as a textbook for 5 years with the decision of the Ministry of National Education (MoNE), Board of Education and Discipline Board. Before the textbooks were selected, 6 teachers working in different provinces were asked which

textbooks were sent to their schools. According to the answer from the teachers, those 4 science textbooks were selected for this study.

All science textbooks include 7 units including same topics with different depths of knowledge as listed in Table 3.2.

Table 3. 2. Content of 5th, 6th, 7th, and 8th-grade science textbooks.

	Content of 5 th Grade Science Textbook	Content of 6 th Grade Science Textbook	Content of 7 th Grade Science Textbook	Content of 8 th Grade Science Textbook
1 st Unit	Sun, Earth, and Moon	Solar System and Eclipses	Solar System and Beyond	Seasons and Climate
2 nd Unit	The World of Living Things	Systems in Our Body	Cells and Divisions	DNA and Genetic Code
3 rd Unit	Measurement of Force	Force and Movement	Force and Energy	Pressure
4 th Unit	Matter and Change	Matter and Heat	Pure Substances and Mixtures	Matter and Industry
5 th Unit	Propagation of Light	Sound and Features	Interaction of Light with Matter	Simple Machines
6 th Unit	Human and Environment	Systems in Our Body and Health of Systems	Reproduction, Growth, and Development in Living Things	Energy Conversions and Environmental Science
7 th Unit	Electrical Circuit Components	Transmission of Electricity	Electrical Circuits	Electrical Charges and Electrical Energy

For example, the first unit of each level is about the Earth and Universe. The other units of each grade continue with the living being and life, physical phenomenon, matter and its nature, physical phenomenon, living beings and life, and physical phenomenon topics respectively. The similar sequence of the topics in each grade is in line with the Bruner's

spiral curriculum approach that is about the revisiting of the same contents over the students' educational life by putting deeper knowledge on the knowledge gathered from the previous grades. Also, each unit is divided into different sections. Sections of each unit and subtitles of the sections were given in Appendix D, Appendix E, Appendix F, and Appendix G for each grade level from the 5th-grade to the 8th-grade respectively.

3.3.2. Sampling of Teachers

The participants for the interviews were selected conveniently. The convenience sampling which is the nonrandom sampling method was found suitable to select the participants because of their accessibility and willingness to participate in the study (Creswell, 2002). The main criteria to be a participant in this study is to be working as a science teacher actively. The novice teachers who have 1-5 years of teaching experience, the intermediate teachers having 6-10 years of teaching experiences and the experienced teacher having more than 10 years of teaching experiences were selected to provide diversity among the participants. Also, the number of male and female participants were considered while selecting the science teachers.

Five teachers were selected by considering that they work in public schools and 3 teachers who work in private schools were selected. Consent forms were sent via an e-mail, phone and social media platform to the science teachers who are working in the schools where the researcher work and teachers who were contacted before in different settings to inform the teachers about the study.

3.4. Data Analysis

The data collected through the science textbooks and teacher interviews were analyzed by using content analysis and thematic analysis methods, respectively. In this section, the procedures of content analysis of science textbooks and thematic analysis are explained in detail.

3.4.1. Content Analysis of Science Textbooks

In the preparation phase, the unit of analysis was selected. Then, the analysis matrices were created as a rubric based on the categories existed in Reconceptualized Family Resemblance Approach to Nature of Science (RFN) (see Appendix H).

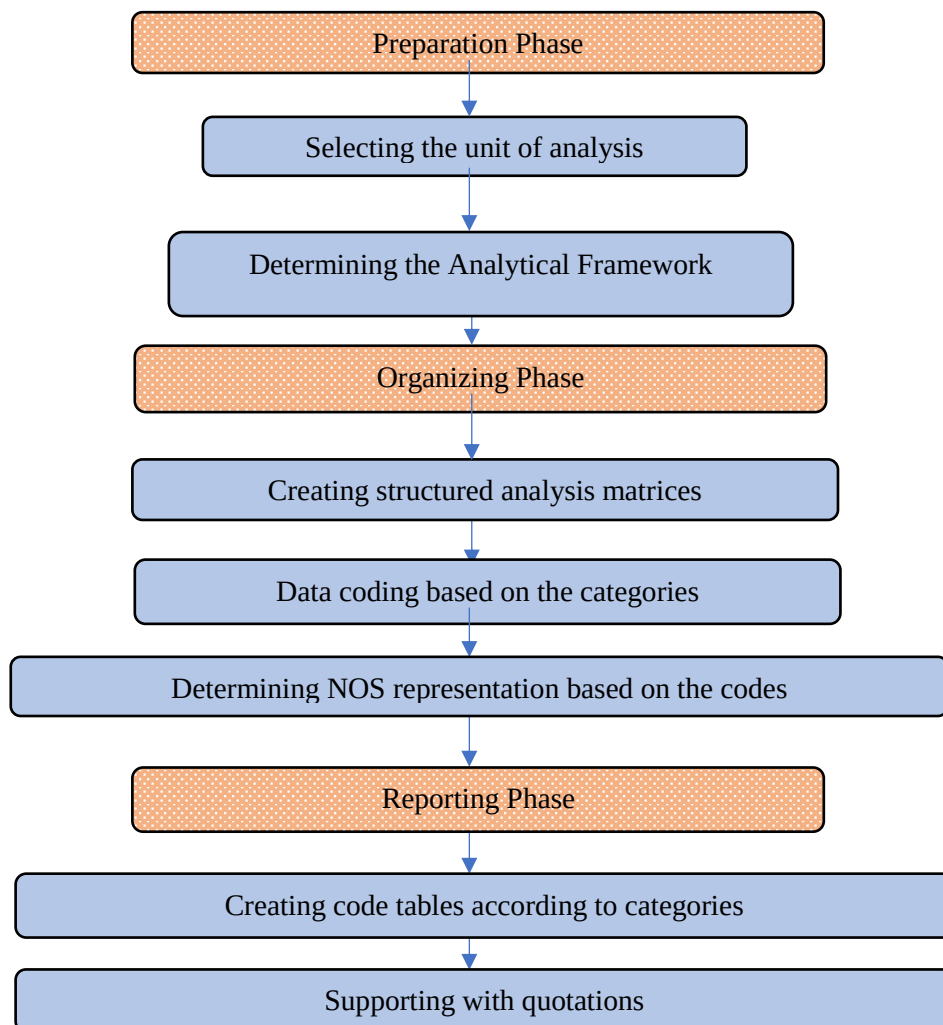


Figure 3. 1. Preparation, Organizing and Reporting Phases of the Study.

Adapted from: [Elo & Kyngäs, 2008, p. 110]

Data coding was done according to the categories in the organizing phase. Then, the representation of the nature of science was stated based on the codes created explicitly or implicitly. Lastly, according to the codes, the tables were formed in the reporting phase and

quotations were given to support each code that shows the representation of NOS in the analyzed textbooks.

3.4.1.1. Selecting Unit of Analysis. According to the Krippendorff (2004) “coding units are units that are distinguished for separate description, transcription, recording, or coding” (p. 99). To analyze the raw data, the textbooks should be divided into units to be coded. The sample is so large to be analyzed with providing reliability hence the textbooks should be divided into coding units which are smaller than whole textbooks. Dividing the texts into small segments also provides a consensus among coders (Krippendorff, 2004). Since the units were analyzed and coded separately.

The coding units were determined by the researcher as follows:

- Paragraphs
- Sentences
- Figures
- Diagrams
- Photos
- Text-based questions
- Steps of activities

These coding units were traced in the content, activity, assessment, laboratory security, and science, engineering and entrepreneurship applications sections (SEEA). The content section includes subjects and concepts that are taught to students, interesting brief information on the subject, some of the explanations about some branches of science and their relationship with the lives of students etc. The activity section includes experiments, observations, discussions, research and other activities that students do on the subject. The assessment section includes assessment questions at the end of the subjects and chapters. Although the emphasis on SEEA is given in the introduction part of the textbooks, the activities for SEEA are also given throughout the chapters of the textbook. Therefore, the activities carried out under the title of SEEA in the units are examined under the activity section and the historical stories under the content sections. However, the SEEA section, which was given independently of the chapters at the beginning of the textbooks, was analyzed within itself and the results were presented independently.

3.4.1.2. Analytical Framework. The analytical framework of this study is based on Erduran and Dagher's (2014a) "Family Resemblance Approach to NOS" which was later termed as "Reconceptualized FRA to NOS" or 'RFN' by Kaya and Erduran (2016). NOS is defined as a cognitive epistemic and social-institutional system by the RFN. The RFN aims to teach the NOS holistically. RFN includes 11 categories of NOS such as "aims and values", "scientific practices", "methods and methodological rules", "scientific knowledge", "professional activities", "scientific ethos", "social certification and dissemination", "social values of science", "social organizations and interactions", "political power structures" and "financial systems". The codes generated in the analysis process were put into the themes which are the RFN categories.

There is a brief description of each category of NOS in Table 3.3. Each coding unit were analyzed with the basis of these categories. There are some initial keywords to facilitate the data collection procedure.

Table 3.3. Brief descriptions of RFN categories.

Source: [Kaya & Erduran, 2016, p. 1123]

RFN category	Description	Keywords
Aims and values	The key cognitive and epistemic objectives of science, such as accuracy and objectivity	Aim, value, goal, accuracy, objectivity
Methods	The manipulative as well as non-manipulative techniques that underpin scientific investigations	The method, scientific method, inquiry, process, hypothesis, manipulation of variables
Scientific practices	The set of epistemic and cognitive practices that lead to scientific knowledge through social certification	Observation, experimentation, data, explanation, model, argumentation, classification, prediction
Scientific knowledge	Theories, laws, and explanations that underpin the outcomes of the scientific inquiry	Knowledge, scientific knowledge, formulation of knowledge, theory, law, model

Table 3.3. Brief descriptions of RFN categories (cont.).

Scientific ethos	The norms that scientists employ in their work as well as in interaction with colleagues	Scientific norms, ethics, bias, being skeptical, caution against bias
Social values	Values such as freedom, respect for the environment, and social utility	Culture, cultural, social values, society, beliefs, freedom, respect
Professional activities	How scientists engage in professional settings such as attending conferences and doing publication reviews	Conference, article, presentation, writing, publishing, publication
Social organizations and interactions	How science is arranged in institutional settings such as universities and research institutes	University, research center, institution, organization
Financial systems	The underlying financial dimensions of science including the funding mechanisms	Financial, funding, finance, economy, economical, budget
Political power structures	The dynamics of power that exist between scientists and within science cultures	Political power, research team, team leader, team members, researcher, gender, ethnicity, race, nationality

The coding units were traced to find these keywords and also new keywords were produced as a code during the data collection processes. For example, when the researcher encountered the accuracy verb, the researcher looked at the meaning behind it. Then, the data were coded as accuracy to place in the aims and values theme. The criterion for coding is also explained in the rubric (see Appendix H).

3.4.1.3. Analysis Procedures. There are no exact rules to analyze the data in the content analysis method, but the texts should be broken to pieces (Weber, 1990). Firstly, the chapters and subtitles were identified in the 5th-grade science textbook. Then, one chapter were selected randomly to be analyzed by another coder. The online version of the selected chapter was sent to another coder. The whole coding units were specified for each page in the chapters individually. Then, coding units were analyzed based on the rubric (see Appendix H). Each coding unit was traced to find initial codes which can be put into RFN

categories. After completing the analysis of the randomly selected chapter, the reliability test was done and percent agreement among to coders was found 88%. This value considered acceptable for interrater reliability (Miles & Huberman, 1994).

Then, the researcher continued to analyze other chapters of the textbook. After determining the coding units of the other chapters, the paragraphs, sentences, figures, diagrams, photos, text-based questions and steps for activities were reviewed for content and they were coded based on the RFN categories (Figure 3.2) which are the analytical framework of this study. Then, the initial codes were grouped to reduce the number of codes by considering their similarities and dissimilarities according to the RFN categories (Burnard, 1991).

RFN Categories	Codes	Pages	Quotation	Explicit/Implicit
AV				
SP				
M				
SK				
SCD				
PA				
SE				
SV				
SOI				
FS				
PPS				

Figure 3. 2. Structured Analysis Matrix.

Each code was noted on the coding units with colorful pans and the supporting sentences of the codes was highlighted. After completing the first chapter, the codes such as accuracy, financial, method and data were noted in a rubric. In the rubric, the page numbers with the codes were also be specified. Quotations were provided for each code found at the

same time. Then each code was put into the themes such as “aims and values”, “scientific practices”, “methods and methodological rules”, “scientific knowledge”, “professional activities”, “scientific ethos”, “social certification and dissemination”, “social values of science”, “social organizations and interactions”, “political power structures” and “financial systems”. The same steps were followed for other chapters, and textbooks respectively. The interrater reliability for 6th, 7th and 8th-grade science textbooks was found 90%, 82%, and 84% respectively.

3.4.2. Thematic Analysis of Teacher Interviews

In qualitative research, the data were prepared and organized to analyze the meanings behind it. (Creswell, 2007). The teacher interviews were analyzed by using thematic analysis which is defined as “method for identifying, analyzing, and reporting patterns (themes) within data” (Braun & Clarke, 2006, p.79) and the process of thematic analysis such as transcription, coding, analysis and written report were followed to analyze teacher interviews.

The data gathered from the interview was transcribed step by step by listening to all interview sections carefully. The transcribed responses were read two times to have a deeper understanding of the participants' views and to be familiar with the data. The unrelated parts of the answers were eliminated, and the data was divided into the expressive parts to named them as codes. The initial codes were produced based on the participants' responses. The initial codes are important to identify the characteristics of the data. According to the Boyatzis “the most basic segment, or element, of the raw data or information that can be assessed in a meaningful way regarding the phenomenon” (1998, p.63).

Later, similar ones from the generated codes were renamed to create cohesion between the codes. For the first part of the interviews, the RFN categories were the themes of the study and each code generated were placed on these themes. Thus, it was revealed which codes exist for each category. For the 2nd and 3rd parts of the study the same process was followed, and codes were explained with quotations in the result chapter. The interrater reliability was checked among two coders and percent agreement was found 92%.

3.4.3. Descriptive Analysis of NOS Questionnaire

One week after the teacher interviews were completed, the “NOS Questionnaire” was delivered to the teachers online. The reason for administrating the questionnaire one week later is to minimize the impact of the questions asked in the interview on the teachers' answers in the questionnaire. After the teachers completed the questionnaire, all the data were transferred to the Excel file and the total score of the teachers got from the questionnaire was determined. At the same time, the mean of the scores obtained by the teachers were calculated separately for each category in the questionnaire.

3.5. Trustworthiness

The credibility of the results is one of the most significant criteria for scientific research. Although validity and reliability are the two most commonly used criteria in research, Guba and Lincoln gave more importance to the trustworthiness term in the qualitative studies (1998). It is suggested to specify one or more of the strategies such as credibility, transferability, dependability, and confirmability in research to check the accuracy of the findings (Guba & Lincoln, 1998).

Trustworthiness is an important part of the qualitative studies. The sampling processes, data collection, and analysis processes were explained in detail for the readers to understand each process, reveal the strengths and limitations of the study and to establish the connection between the data and the results.

To conduct a successful content analysis study, the researcher must collect and analyze the data which are suitable for the subject of the study reliably and place these data in appropriate categories with generating the codes (Kynga's & Vanhanen 1999). All these stages were carried out in this study step by step. To talk about the credibility of the research findings, the extent to which the categories cover the data should be considered (Graneheim & Lundman 2004). Therefore, while analyzing the data, the categories in which the data put into were supported with examples from the textbooks. Showing the links between the data and the result is important to provide the credibility of the study. The graphs were created to

demonstrate the connections between the data and the results of the study (Graneheim & Lundman 2004).

The meanings of verbal or visual data are explained by the content analysis method. Although this method helps us with the analysis of the textbooks, it is necessary to be careful about reliability. Creating codes or reaching different results other than the meaning of the content may impair the reliability of results. Therefore, there are issues related to the reliability of data and coding systems to be considered in the process of content analysis.

According to Krippendorff (1980) and Weber (1990) stability over time and reproducibility is an important factor to provide the reliability of the content analysis. The researcher recoded some of the parts of the content at different times to determine the stability over time. Thereafter, the researcher compared the codes which were gathered from the same content that was encoded twice at different times. In this way, the stability of codes was achieved over time. Certain rules must be presented and followed in the coding and transcribing process to provide accuracy among the codes.

Reproducibility is the determination of reliability between encoders. With this method, apart from the researcher, another coder encoded some of the raw data in chapters randomly selected from each textbook independently. After percent agreement was found in desired range, it meant that there is an agreement between the coders. Then, the researcher coded the remaining chapters individually.

Also, the data gathered from the teacher interviews were analyzed by one coder besides the researcher of the study. The coder who is a master student in science education took a course on nature of science in science education which covers the RFN approach in detail and also was conducted a study on RFN for her thesis.

Qualitative studies do not give more importance to a generalizability issue (Myers, 2000). The experiences of the participants, characteristics of participants and sample selection was defined in detail to prove the transferability in qualitative research so that those who read the study can apply the results in their work. Also, the expert critically looked at

the processes from the design of the research to the data collection, analysis and the writing of the results, and gives feedback to the researcher to provide credibility.

3.6. Ethical Considerations

Ethical consideration is an important part of this study. The ethical guideline presented on the Social and Human Sciences Human Research Ethics Committee (SBINAREK) was considered during the study. Approval of the ethical committee and permission from Ministry of National Education of Turkey were received before conducting this study.

In this study, there was no potential damage and harm to any of the participants. The dignity of the participants was the priority of this study. The voluntary participation of the participants is an important issue so the informed consent form (see Appendix I) which is given to all participants before starting to collect data were received. Also, all participants were informed to have a right to withdraw from the study without giving any excuses. The privacy of the participants was provided in all parts of the study. Anonymity and confidentiality of both participants and data were ensured. Information about participants who participated in the interview section was kept confidential by providing nickname consisting of the first two letters of first and last names of participants. After the study ends, the name of the participants or other personal information will not be used in publications or presentations from the results of the study.

4. RESULTS

This chapter includes the 2 sections which are results of the content analysis of the 5th, 6th, 7th and 8th grade science textbooks and results of the science teachers' perceptions on NOS and science textbooks.

4.1. Results of the Content Analysis of the Science Textbooks

The first research question and its sub questions of the study are answered under this section. This section includes the overall evaluation of NOS in the science textbooks for each grade level separately and the representation of NOS in the science textbooks under separate subheadings for the 11 categories of science for each grade level independently. Also, the representation of NOS in science, engineering and entrepreneurship applications sections in each science textbook is given after presenting the results of the 11 categories of science.

4.1.1. Overall Evaluation of NOS in the Science Textbooks

In this section, the overall evaluation of NOS in each science textbook is presented with figures including the frequency of the codes under each RFN category. In this section, the frequency of the codes for each category in each science textbook, the frequency of the codes in each unit of science textbook, the frequency of the codes for content, activity and assessment sections of each science textbook are presented.

4.1.1.1. Overall Evaluation of NOS in the 5th-Grade Science Textbooks. Figure 4.1 including the frequency of the codes for each category of RFN shows that 196 codes were generated from a 5th-grade science textbook. According to the figure, almost 3/4 of the 196 codes have accumulated in the “scientific practices (SP)” category ($f = 124$).

More codes were created in the epistemic and cognitive categories of science than in the social categories. Codes for “scientific knowledge (SK)” ($f = 12$) and “method and methodological rules (M)” ($f = 12$) are found in equal numbers throughout the book. However, the “aims and values (AV)” of science ($f = 3$) is one of the epistemic and cognitive categories with the least emphasis and the least number of codes. Although the total emphasis on epistemic and cognitive categories is more than social categories, “social certification and dissemination (SCD)” ($f = 23$) is the most coded category. Also, there are some codes for “professional activities (PA)” ($f = 11$) and “social organizations and interactions (SOI)” ($f = 6$) categories. While 3 codes for “social values (SV)” and 1 code for “political power structures (PPS)” and “financial systems (FS)” were created, no codes were created for “scientific ethos (SE)”.

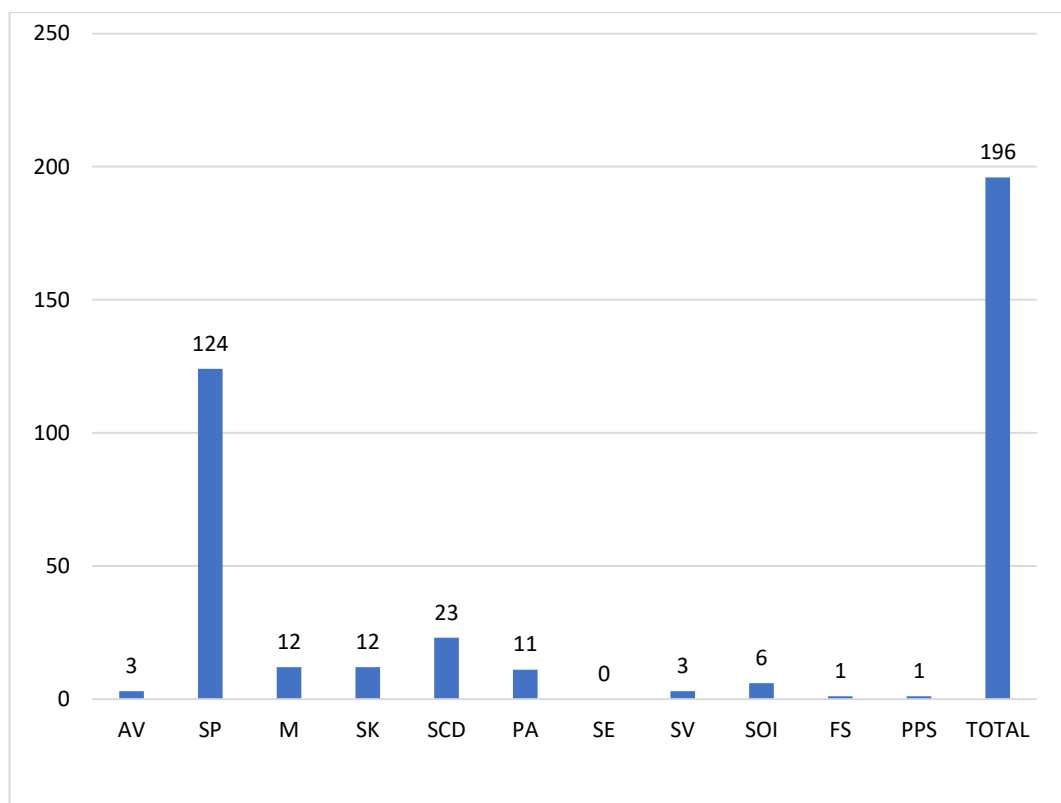


Figure 4.1. The Frequency of the Codes for Each RFN Category in the 5th-Grade Science Textbook.

Figure 4.2 shows how the categories of RFN are distributed into the units of the 5th-grade science textbook. According to the figure, the emphasis on NOS was made in the 6th unit, which includes the subject area of living things and life, ($f = 41$) at most. This might be

because there are more objectives in the 6th unit than other units based on the science curriculum published by the Ministry of National Education (MEB, 2018). The frequency of the codes on 4th unit ($f = 33$), 5th unit ($f = 34$) and 1st unit ($f = 30$) are almost equal. While fewer codes of NOS are detected from the 3rd ($f = 22$) unit and 7th unit ($f = 20$), the least number of codes is present in 2nd unit, which includes the subject area of physical events ($f = 16$).

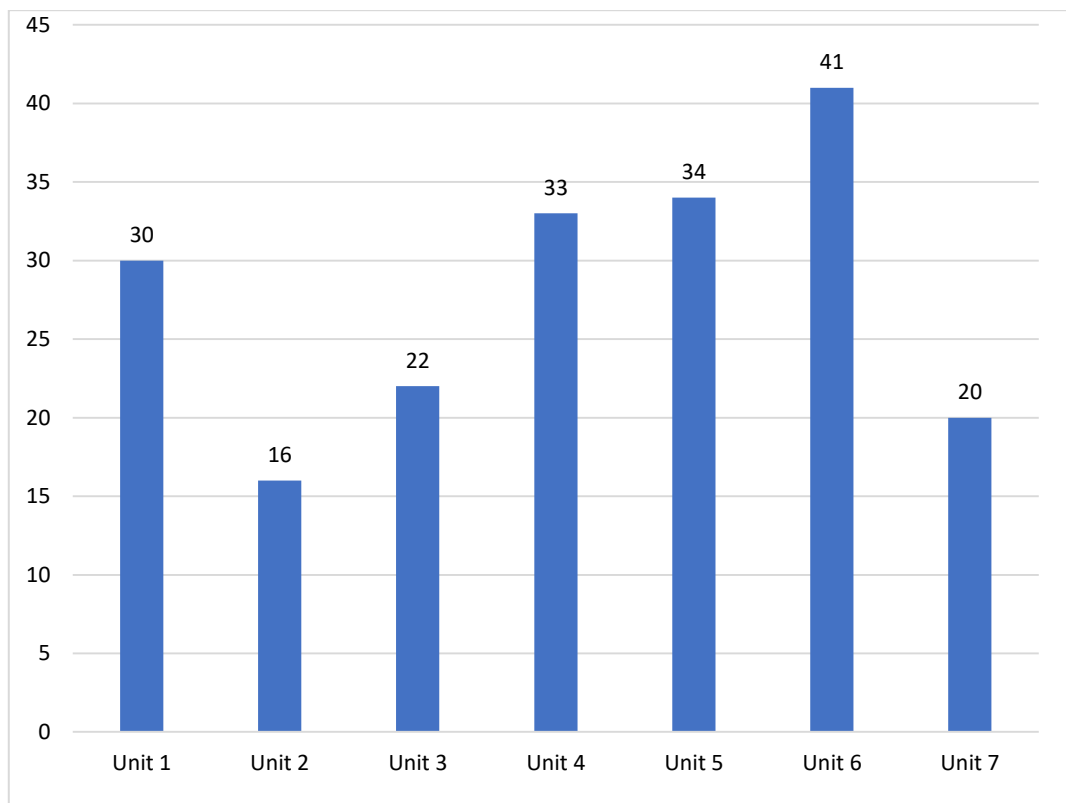


Figure 4.2. The Frequency of the RFN Codes for Each Unit of the 5th-Grade Science Textbook.

The frequency of the codes in the activities, content, and assessment sections of the 5th-grade science textbook is represented in the Figure 4.3. The figure shows that 132 of the codes were detected in the activity sections, 43 in the content sections, and 21 in the assessment sections. The frequency of the codes under the “scientific practices (SP)” was found most in the activity sections of the textbook ($f = 90$) than content and assessment sections ($f = 14$; $f = 20$). In addition, 9 of the 12 codes created for the “method and methodological Rules (M)” were created from the activity sections of the textbook. On the contrary, the codes of “aims and values (AV)” and “scientific knowledge (SK)” were found

in the content sections at most. The codes for “professional activities (PA)” and “social certification and dissemination (SCD)”, which are the most mentioned social categories, were generally created in the activity sections. Apart from this, it has been determined that the “social values (SV)”, “social organizations and interaction (SOI)”, “financial systems (FS)” and, “political power structures (PPS)” which have very few codes in total, are mentioned in the content sections.

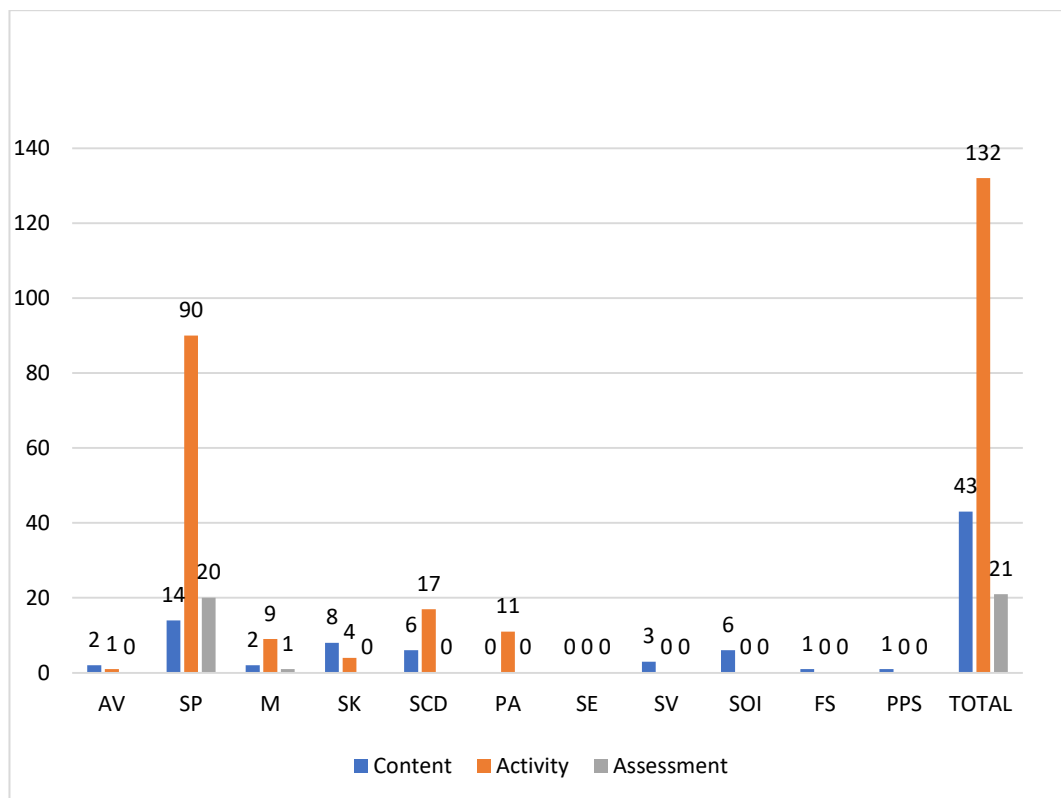


Figure 4.3. The Frequency of the Codes for Content, Activity and Assessment Sections of the 5th-Grade Science Textbook.

To sum up, codes generated in the 5th-grade science textbooks are generally revolving around epistemic and cognitive aspects of science instead of social categories of science. However, there are also some significant differences among the representation of categories. SP is the most highlighted category in both activity and assessment sections of the textbook than other categories. There are also some exceptions for social categories because SCD and PA are represented in the activity parts of the textbook.

4.1.1.2. Overall Evaluation of NOS in the 6th-Grade Science Textbook. Figure 4.4 shows how the RFN categories are spread throughout the 6th-grade science textbook. Looking at the figure, it can be said that 331 of the 545 codes created in total belong to the “scientific practices (SP)” category. Throughout the 6th-grade science textbook, 11 codes were created from the “aims and values of science (AV)”, while 56 and 23 codes were created from “methods and methodological rules (M)”, and “scientific knowledge (SK)”, respectively. Although there is a lack of social categories throughout the textbook, “social certification and dissemination (SCD)” and “professional activities (PA)” categories are included with 49 and 56 code repetitions throughout the textbook. However, in contrast to this, code numbers between 2 and 8 were detected in other social categories such as “social values (SV)”, “scientific ethos (SE)”, “social organizations and interactions (SOI)”, “financial systems (FS)”, and “political power structures (PPS)”.

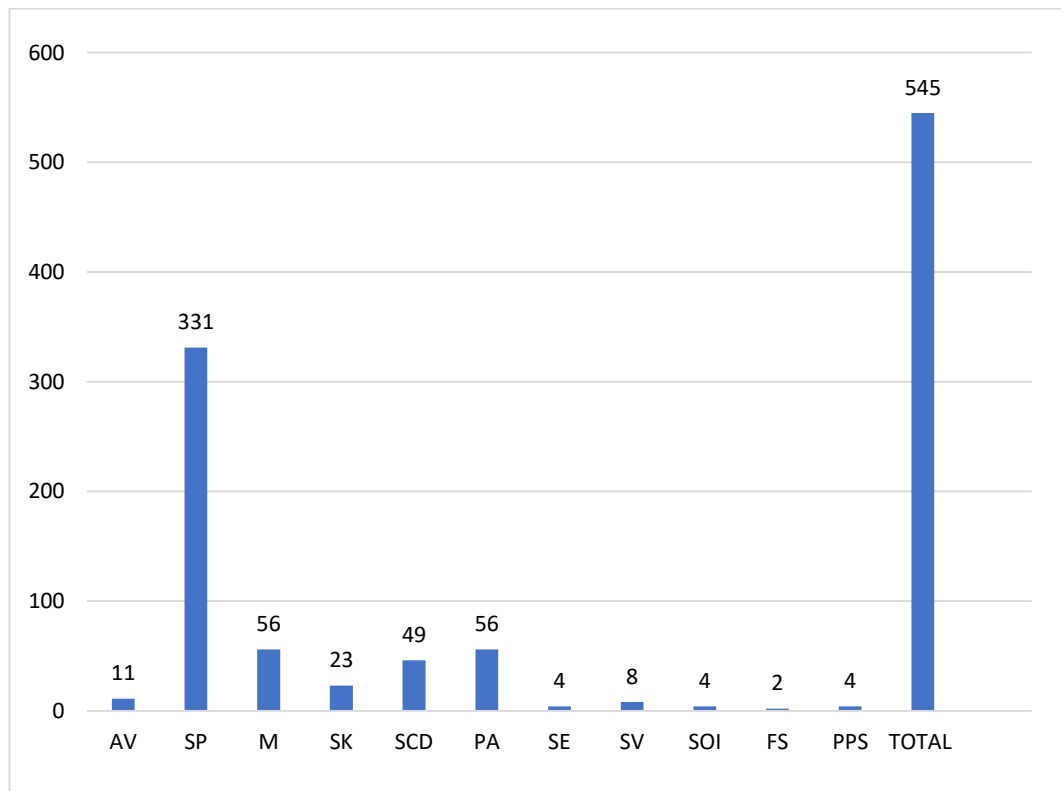


Figure 4.4. The Frequency of the Codes for Each RFN Category in the 6th-Grade Science Textbook.

According to Figure 4.5, which shows the distribution of 545 codes to units, it is seen that most of the codes were formed from the 4th unit, which includes the subject area of

matter and nature, and the 6th unit, which includes the subject area of living things and life. The reason for this result might be because there are more objectives in the 4th unit than other units and 6th unit is the second unit with a high number of objectives based on the science curriculum published by the Ministry of National Education (MEB, 2018). In addition, the fact that the 4th and 6th units include too many pages than other units in the textbook may be another reason for this.

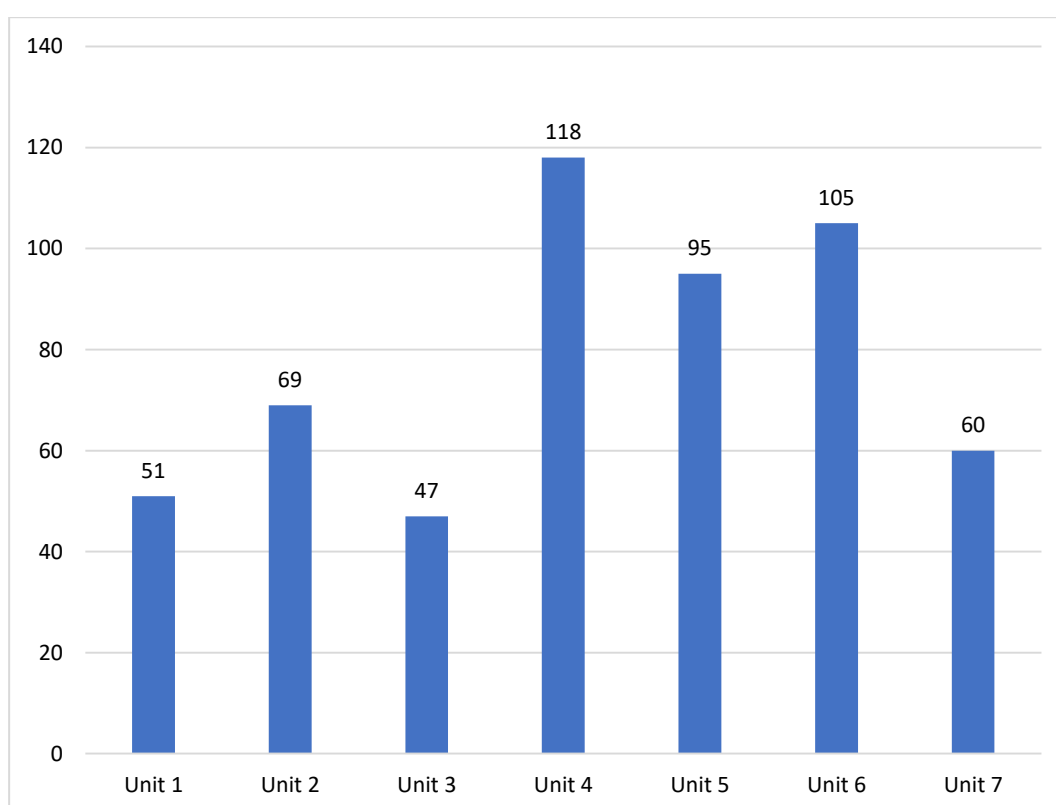


Figure 4.5. The Frequency of the RFN Codes for Each Unit of the 6th-Grade Science Textbook.

Although the 6th-grade science book contains RFN categories, it is also important in which parts of the textbook the codes are determined. Figure 4.6 shows that 359 of 545 codes in total were created in the activity sections, 113 in the assessment sections, and 73 in the content sections. According to the figure, references to “scientific practices (SP)” ($f = 226$), “methods and methodological rules (M)” ($f = 49$), “social certification and dissemination (SCD)” ($f = 39$), and “professional activities (PA)” ($f = 43$) are mostly found in the activity sections, while the remaining categories are generally represented in the content sections. In

addition, while there are generally codes belonging to SP in the assessment sections of the textbook, references to the M are also found in these sections.

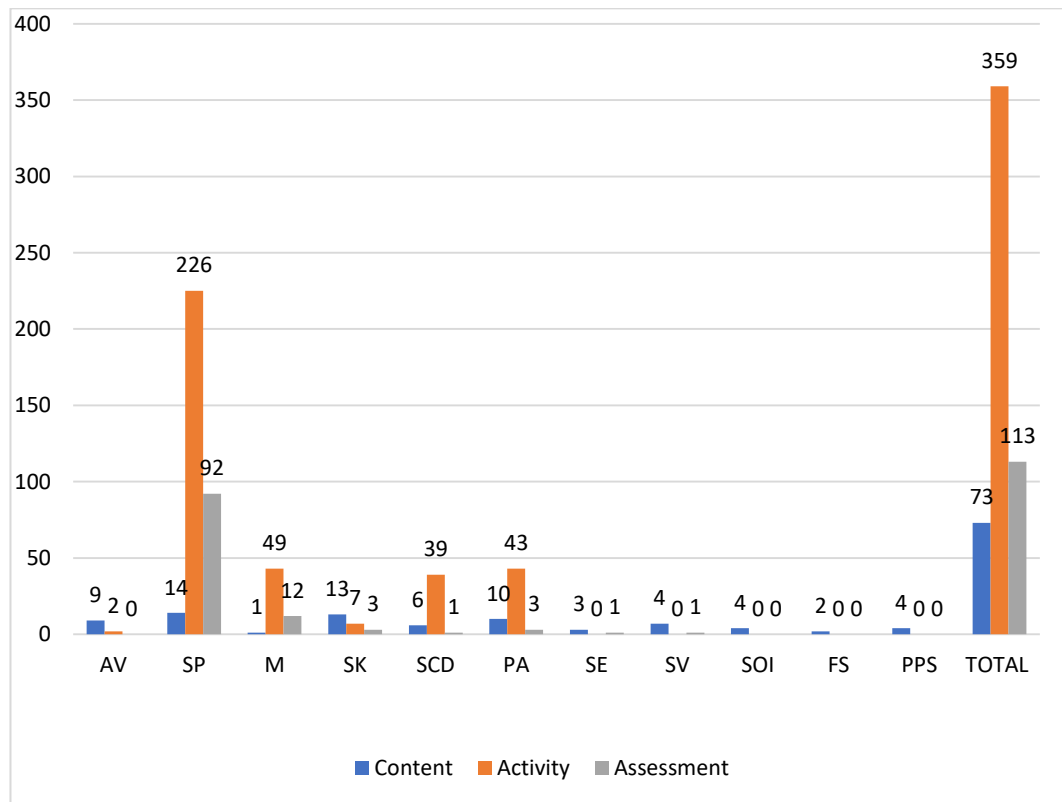


Figure 4.6. The Frequency of the Codes for Content, Activity and Assessment Sections of the 6th-Grade Science Textbook.

To sum up, the codes ($f = 545$) generated in the 6th-grade science textbook are generally revolving around the epistemic and cognitive aspects of science instead of social categories of science. However, there are some exceptions for SCD and PA which have a higher frequency of the codes than other social categories, and some cognitive and epistemic categories such as AV and SK. According to the results, SP is the most highlighted category in both activity and assessment sections of the 6th-grade textbook than other categories.

4.1.1.3. Overall Evaluation of NOS in the 7th-Grade Science Textbook. According to Figure 4.7 showing the frequency of the codes for each RFN category in the 7th-grade science textbook, the majority of the total code ($f = 284$) generated is from “scientific practices (SP)” ($f = 160$). A very limited number of codes have been found for the “aims and values of science (AV)” ($f = 2$) from the epistemic and cognitive categories of science. Also, there are

42 codes for “methods and methodological rules (M)” and 22 codes for “scientific knowledge (SK)” categories. Among the social categories, the most codes were found in the “professional activities (PA)” ($f = 26$) and the “social organizations and interactions (SOI)” categories, while very few codes were found for other categories which are “social certification and dissemination (SCD)” ($f = 7$), “scientific ethos (SE)” ($f = 2$), “social values (SV)” ($f = 4$), “financial systems (FS)” ($f = 3$) and “political power structures (PPS)” ($f = 2$).

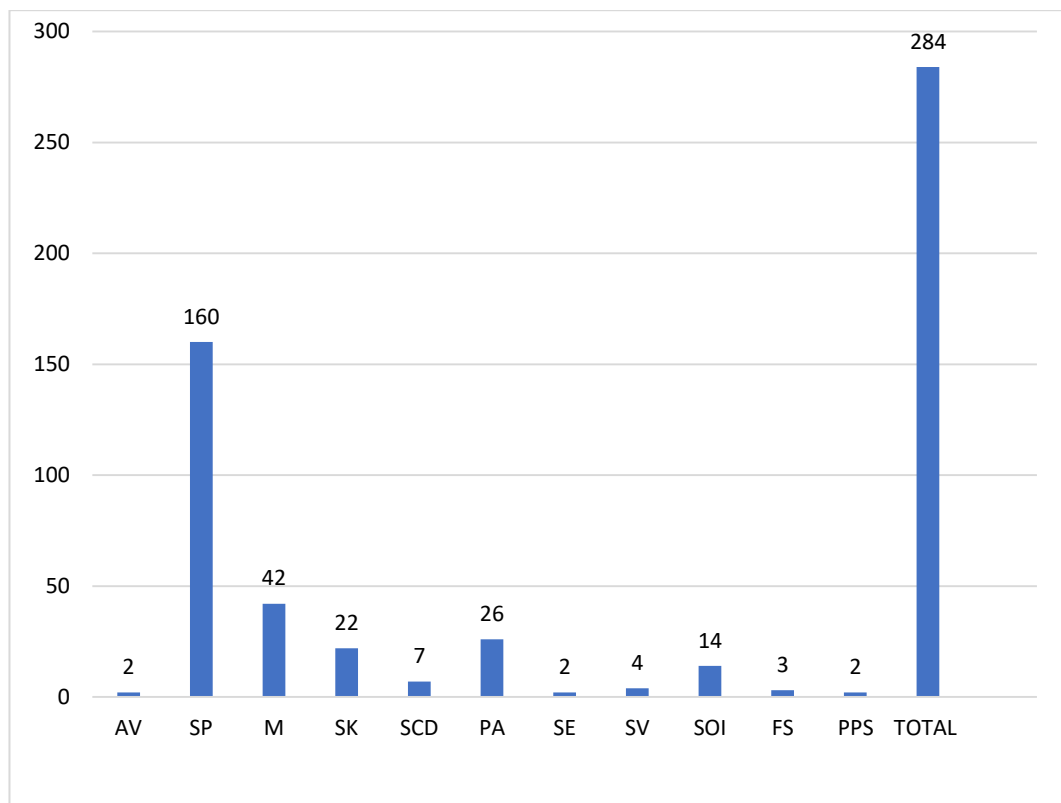


Figure 4.7. The Frequency of the Codes for Each RFN Category in the 7th-Grade Science Textbook.

According to Figure 4.8, which shows the distribution of 284 codes, it is seen that most of the codes were formed from the 7th ($f = 53$) and 5th ($f = 50$) units, which include the subject area of physical events. The reason that the number of codes in these units is higher than in other units may be that physics topics include more experiments and activities in textbooks. On the other hand, the least number of codes were created in 2nd ($f = 25$) and 6th ($f = 30$) units which include the subject area of living things and life. The reason for this result may be that fewer activities and experiments on biology topics might be included while the science textbooks were being prepared.

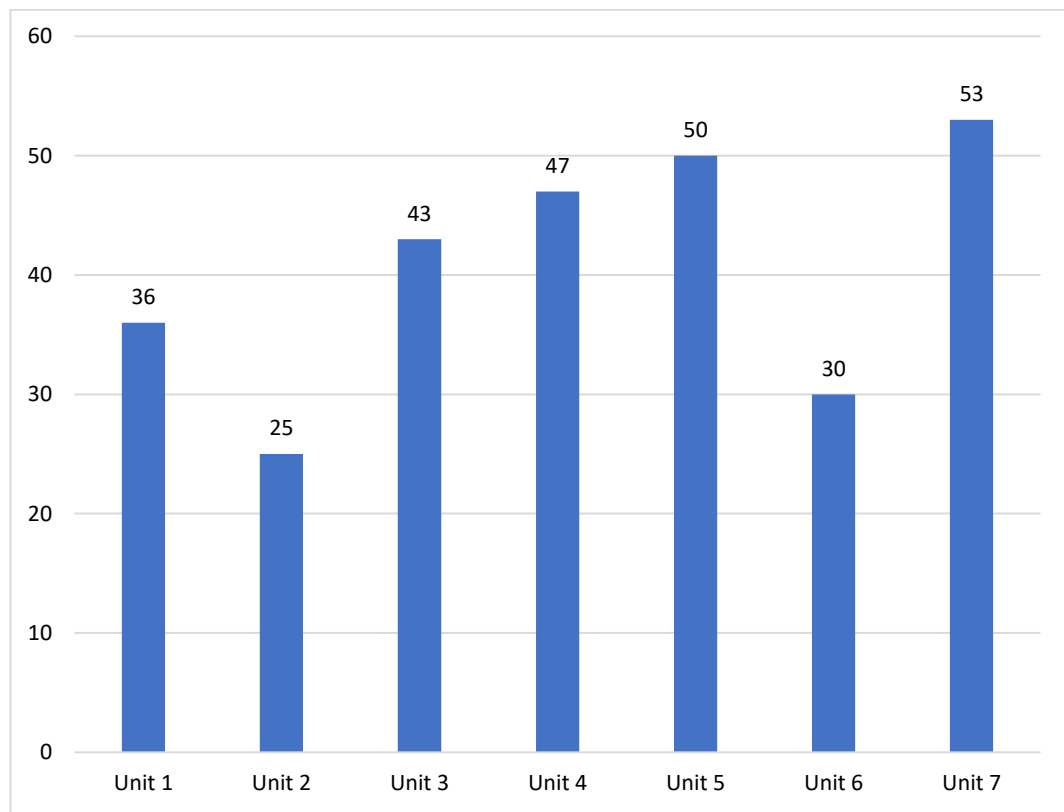


Figure 4.8. The Frequency of the RFN Codes for Each Unit of the 7th-Grade Science Textbook.

Figure 4.9 shows that 189 of 284 codes in total were created in the activity sections, 68 in the assessment sections, 27 in the content sections. According to the figure, references to “scientific practices (SP)” ($f = 133$), “methods and methodological rules (M)” ($f = 30$), and “professional activities (PA)” ($f = 18$) are mostly found in the activity sections, while the remaining categories are generally represented in the content sections. Besides, the social categories of science are not represented in the assessment sections of the 7th-grade science textbook whereas references of SP, M, and SK which are epistemic and cognitive aspects of science are included in these sections.

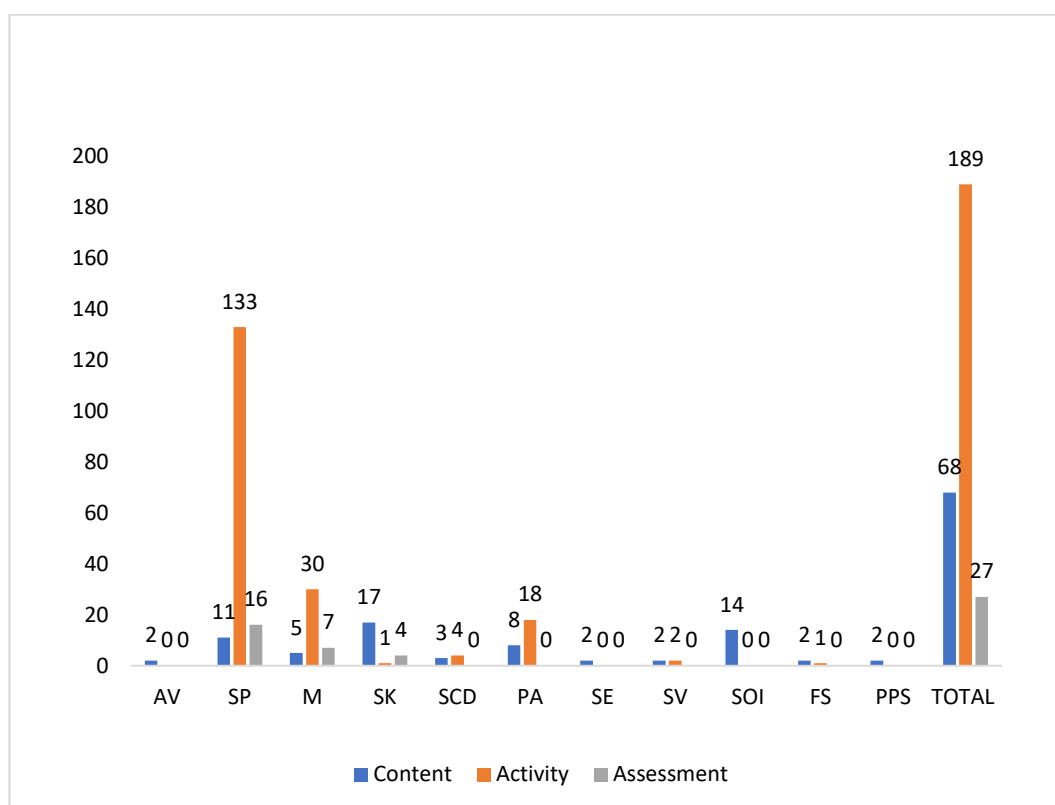


Figure 4.9. The Frequency of The Codes for Content, Activity and Assessment Sections of the 7th-Grade Science Textbook.

To sum up, the codes ($f = 284$) generated in the 7th-grade science textbook are generally revolving around the epistemic and cognitive aspects of science instead of social categories of science. According to the results, most of the codes were found under SP in the activity sections of the 7th-grade textbook than other categories. On the other hand, there are some exceptions for PA and SOI which are included more in the textbooks than other social categories of science. Also, the AV category which is one of the epistemic and cognitive aspects of science does not have more codes in the textbook. Besides, most of the generated codes were found throughout the 7th-grade science textbook and most of the codes under categories were generated from the activity sections. However, the references for SK and SOI categories were found in the content sections of the 7th-grade science textbook.

4.1.1.4. Overall Evaluation of NOS in the 8th-Grade Science Textbook. Figure 4.10 including the number of the codes for each category of RFN shows that 427 codes were generated from 8th-grade science textbook. As can be seen in the figure the number of the codes under the “scientific practices (SP)” ($f = 231$) is higher than the other categories in

whole parts of the textbook. Even though the textbook includes some references about the social categories the number of the codes in the epistemic and cognitive categories are superior to them.

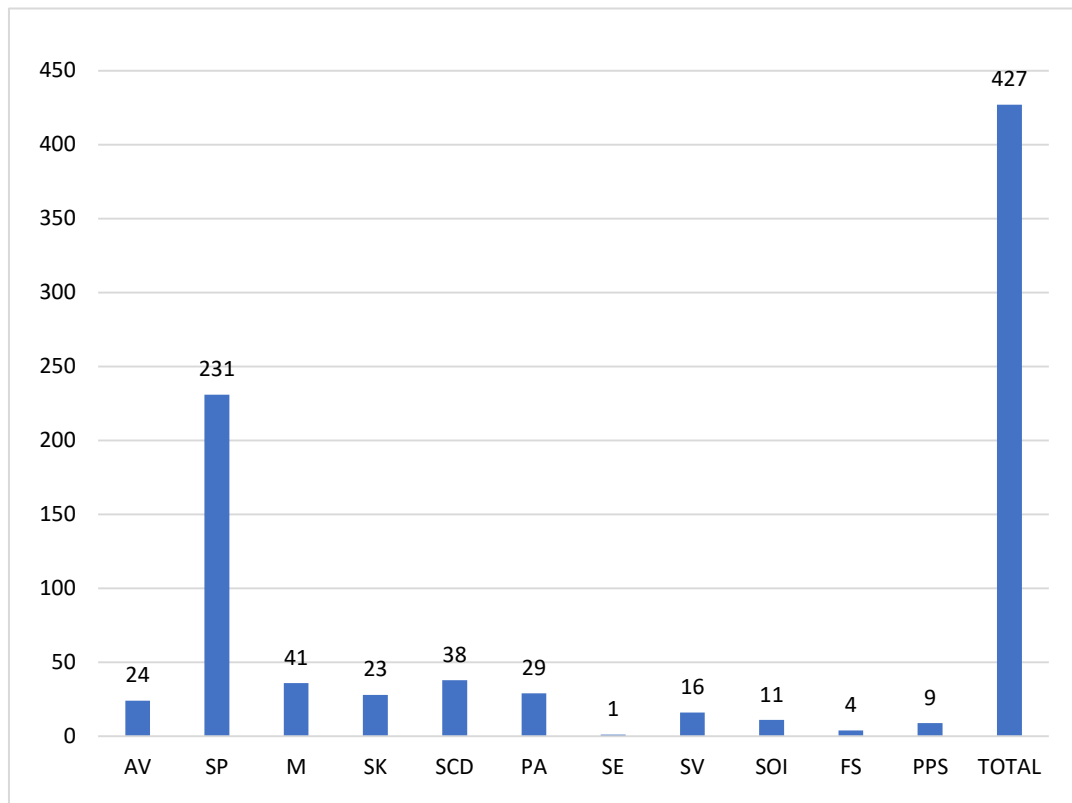


Figure 4.10. The Frequency of the Codes for Each RFN Categories in the 8th-Grade Science Textbook.

The fewest codes were generated under the “scientific ethos (SE)” category ($f = 1$). Subsequently, less code was found in other social categories such as “financial systems (FS)”, “political power structures (PPS)”, “social organizations and interactions (SOI)” and “social values (SV)” respectively. On the contrary, the frequency of the codes under the “professional activities (PA)” category ($f = 29$) was found higher than the “aims and values (AV)” of the science category ($f = 24$) whereas the frequency of the codes under the “social certification and dissemination (SCD)” category ($f = 38$) was found higher than the “methods and methodological rules (M)” ($f = 41$) and “scientific knowledge (SK)” categories ($f = 23$). Also, “professional activities (PA)” and “social certification and dissemination (SCD)” categories are the most highlighted categories among the social categories of RFN.

Figure 4.11 shows how the categories of RFN are distributed into the units of 8th-grade science textbook. According to the figure, the emphasis on NOS was made in the 4th and 6th unit at most. The number of the codes for these units was found 112 and 82 respectively. This might be because in the science curriculum published by the Ministry of National Education (MEB, 2018), the 4th unit, which includes the subject area of matter and nature, has a higher number of objectives and, the 4th and 6th units have more pages than other units of the 8th-grade science textbook. On the contrary, although the number of the pages of 1st and 3rd units is less the number of the codes indicates that their NOS emphasis is higher than the 2nd, 7th, and 5th units. Besides, the figure shows that the units with the most emphasis on NOS belong to a different science branch. This supports that being a subject of biology, physics or chemistry does not mean that it emphasizes the NOS more.

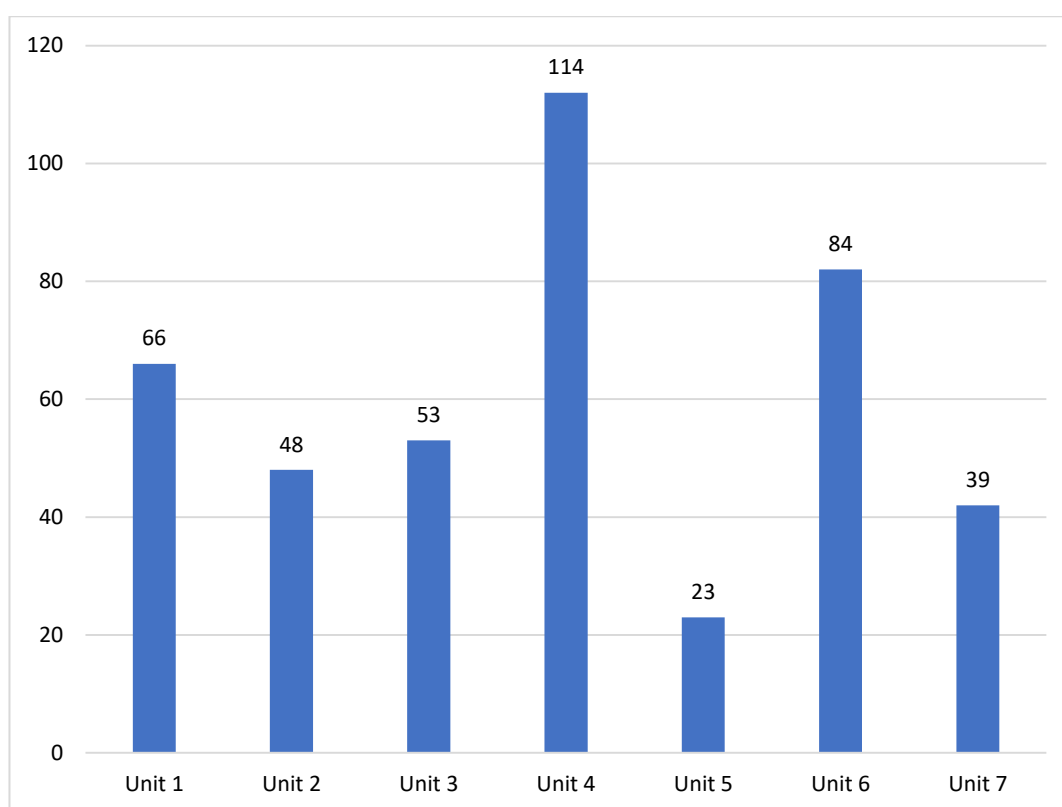


Figure 4.11. The Frequency of the RFN Codes for Each Unit of the 8th-Grade Science Textbook.

The frequency of the codes in the activities, content, and assessment sections of the 8th-grade science textbook is represented in the Figure 4.12. The codes that represent the NOS were generated in the content, activity, and assessment sections of the textbook. The

frequencies of the codes for content, activity and assessment are 124, 280, and 23 out of 427 respectively. The frequency of the codes under the “scientific practices (SP)”, “methods and methodological rules (M)”, “social certification and dissemination (SCD)”, “professional activities (PA)”, “scientific ethos (SE)” was found most in the activity sections of the textbook whereas “aims and values (AV)” of science, “scientific knowledge (SK)”, “social values (SV)”, “financial systems (FS)” and “political power structures (PPS)” were represented most in the content sections of the textbook.

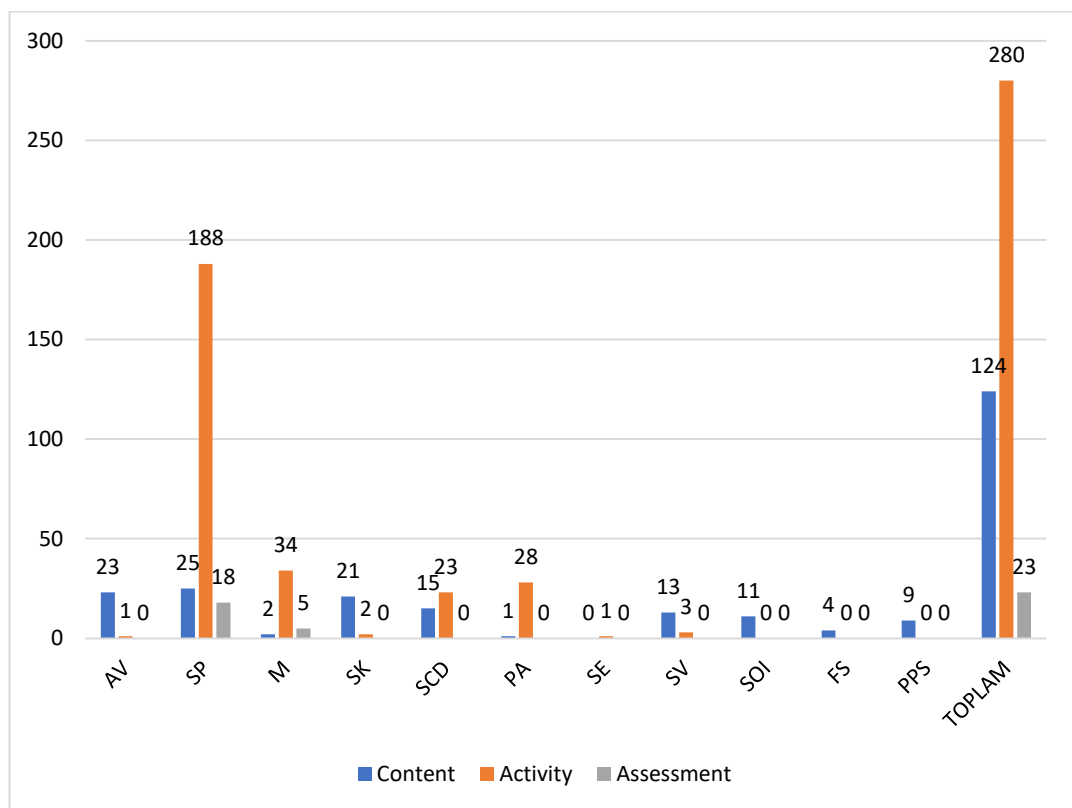


Figure 4.12. The Frequency of the Codes for Content, Activity and Assessment Parts of the 8th-Grade Science Textbook.

It might be said that the 8th-grade science textbook represents the implications of the nature of science in science education for most of the categories but there is also needed to design activities for SE, SV, SOI, FS, and PPS. Also, M, PA and SP would be highlighted most in content sections of the textbook to show how scientists think about those categories. One of the striking results is that there are only references to SP and M categories of RFN were determined in the assessment sections of the 8th-grade science textbook.

To sum up, the representation of NOS in the 8th-grade science textbook is generally revolving around epistemic and cognitive aspects of science instead of social categories of science. However, there are also some significant differences among the representation of categories. Most of the codes were found under the SP category in both the activity and assessment sections of the textbook than other categories. There are also some exceptions for social categories because SCD and PA are represented well in the activity parts of the textbook. Also, it was found that the emphasis on NOS was made in the 4th and 6th units at most.

4.1.1.5. Progression of NOS in the Science Textbooks. Figure 4.13 includes the frequency of the codes showing the progression of NOS across 5th, 6th, 7th and 8th-grade science textbooks. When each category of NOS was examined in the 5th, 6th, 7th, and 8th-grade textbooks, the consistent progression for the NOS ideas was not found in terms of the grade levels. The figure indicates that SP is the most highlighted categories in each grade level science textbook. However, the frequency of the codes for some categories such as AV, SP, M, SK, SCD, and PA were found more in the 6th-grade science textbook when the grade levels are compared for the progression.

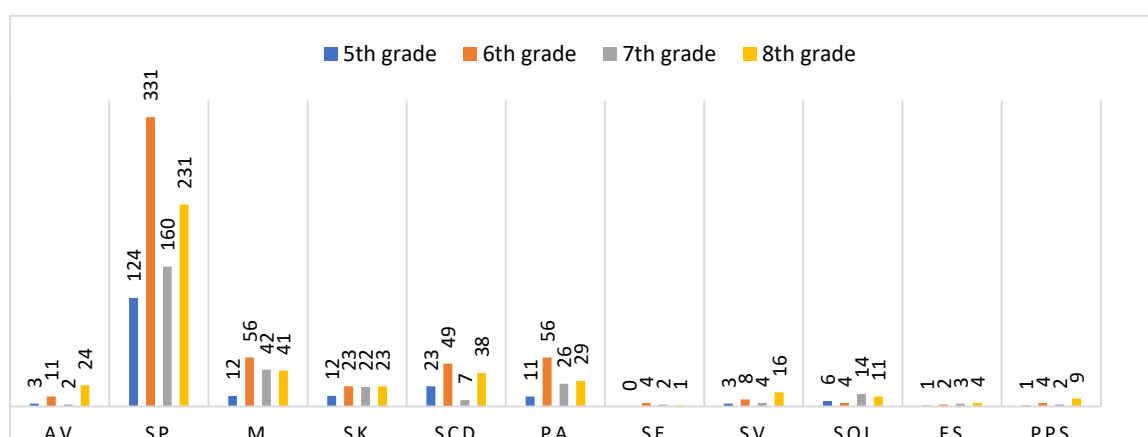


Figure 4. 13. The Frequency of the Codes Showing the Progression of NOS in Science Textbooks.

Even though most of the references for the NOS categories were found in the 6th grade science textbook the progression of the NOS ideas was seen throughout the 5th, 7th and 8th-grade science textbooks. For example, the progression of the NOS references in the AV, SP, PA, SV and FS categories throughout the 5th, 7th and 8th-grade science textbooks was

observed. Shortly, it can be said that those textbooks were not prepared by considering the vertical articulation of NOS ideas which means organization of the NOS contents according to the sequence and continuity of learning over time.

4.1.2. The Representation of NOS in the Science Textbooks

In this section, the generated codes are given in separate subsections including different categories of science. The subsections are presented based on the RFN categories which are “aims and values (AV)” of science, “scientific practices (SP)”, “methods and methodological rules (M)”, “scientific knowledge (SK)”, “social certification and dissemination (SCD)”, “professional activities (PA)”, “scientific ethos (SE)”, “social values (SV)”, “social organizations and interactions (SOI)”, “financial systems (FS)” and “political power structures (PPS)”. The specific codes for each category and their frequency values were given for each science textbook in different sections. In each section, some quotes where the codes were created are included. Also, some information about quotes such as grade level, unit number, and page number were given. While giving quotations some abbreviations were used. Content, activity and assessment sections are abbreviated as CONT, ACT and ASS, respectively, in order to show in which part of the textbook the quotation was formed. In addition, SEEA abbreviation is used for science, engineering and entrepreneurship applications and LS is used for Laboratory Safety. Also, grade level of textbook, unit and page number have been added at the end of the quotation. For example, 5-3-CONT, p. 85 represents that this quotation was taken from content sections of the 3rd unit of 5th-grade science textbook on page 85. Besides, 5-2-ACT, p.44 represents that this was taken from activity sections of the 2nd unit of 5th grade science textbook on page 44.

4.1.2.1. The Representation of NOS in the 5th-Grade Science Textbook. There are 11 subsections including results of the representation of NOS in the 5th-grade science textbook based on each categories of science. Also, there are 2 subsections including examination of science, engineering and entrepreneurship applications (SEEA) and summary of the results of the 5th-grade science textbook.

4.1.2.1.1. The Representation of Aims and Values of Science in the 5th-Grade Science Textbook. The 5th-grade science textbook lacks the emphasis of AV. There are only 3 codes

which are ‘*serving to humanity*’, ‘*curiosity*’, and ‘*novelty*’ under this category. The one code was created from the 2nd unit and two codes were created from the 3rd unit whereas other units do not include any references to NOS. Serving to humanity code is highlighted explicitly in the content part of the textbook as follows.

Sonars, which were developed in order to locate submarines during the Second World War, are useful in many areas such as finding sunken ships, measuring the depths in the sea, determining the location of fish shoals and making underwater maps. [5-2-CONT, p.54]

The codes generated for this category indicates that AV is not represented adequately in the 5th-grade science textbook. There is a need to integrate some aims and values of science such as critical examination, accuracy, objectivity, addressing anomalies and counter instances, challenges taking seriously, honesty and equality of intellectual authority in the 5th-grade science textbook.

4.1.2.1.2. The Representation of Scientific Practices in the 5th-Grade Science Textbook.

While the “scientific practices (SP)” are mostly included in the 4th unit (f = 32), the 2nd unit includes less references to SP (f = 9). The reason for this distribution might be the number of the objectives and lesson hours specified for those units. There are kinds of SP in the 5th-grade science textbook. The 5th-grade science textbook includes mostly ‘observation’ (f = 20) and ‘scientific explanations’ (f = 26) as a practice in this category. The word observation is used in the book as observing the results of experiments that are not manipulative or manipulative rather than observing with a microscope or telescope.

Also, ‘*real world*’ (f = 13), ‘*data*’ (f = 16), ‘*representation*’ (f = 12), and ‘*models*’ (f = 7), are other codes for SP that are highlighted more in the science textbook as an implication of NOS in science education. Although there are modeling activities in the textbook, there are no directions for students to develop and reflect on the model they have created. The practices found in the textbook generally link to each other and work together to produce scientific knowledge. One of the quotes for observation, and scientific explanation codes is as follows.

Let's observe the changes that occur as a result of the heating of fat and wax. What change did we observe in the fat and wax we heated? Let's explain [5-4-ACT, p.83]

This quote indicates that the textbook encourages students to make observations in the real world to explain some situations. Also, there are other quotes for data, representation and scientific explanation as follows.

By turning off the alcohol stove, let's note the value (heated water) of the water on the stove on the thermometer in the table below. Which of the mixed waters gave off heat? Let's explain. [5-4-ACT, p.99]

It also shows that in order to make an explanation scientifically students use data they collected and represented on the table. Besides, there are some other scientific practices that were coded such as '*experimentation*' (f = 3), '*classification*' (f = 5), '*prediction*' (f = 5), '*interpretation*' (f = 1), '*discussion*' (f = 6), '*inference*' (f = 4), '*doing research*' (f = 4), and '*comparison*' (f = 2), which are repeated less than codes mentioned above. Most of them were given as step-by-step directions.

As a summary it can be said that SP, which is an epistemic and cognitive part of science, is represented well than other categories in the 5th-grade science textbook. There are many practices integrated in the textbook and the link between the practices was built well to produce scientific knowledge. The results showed that some of the practices have superiority on others such as observation, scientific explanation, data, real world and representation but there would be balance between the emphases on the practices. Also, those codes were found mostly in the activities and assessment sections to encourage students to produce knowledge. They also can be integrated in content sections to highlight the scientific practices that scientists use in their studies.

4.1.2.1.3. The Representation of Methods and Methodological Rules in the 5th-Grade Science Textbook. "Methods and methodological rules (M)" were represented with a few codes in the 5th-grade science textbook. There are no references that highlight the importance of domain general and domain specificity features of science and textbook does not encourage students to use different methods to reach scientific knowledge or talk about the strength and weakness of the possible methods. In the textbook there is an emphasis on some

‘*variables*’ (f = 3) which are dependent, independent and control variables in the 7th unit as follows.

In our experiments, everything we change or keep constant in order to reach a result is called a variable [5-7-CONT, p.183]

This statement aims to teach what variables are explicitly and also different types of variables are mentioned in the textbook. However, there is no explanation about manipulative testing based on those variables being one of the methods in the science and also there can be non-manipulative testing. Also, ‘*manipulative testing*’ (f = 6) and ‘*constructing hypotheses*’ (f = 3) were found as a code in some of the units of the textbook. Even though those codes were found implicitly the textbook does not include explicit reference to what hypothesis is, how hypotheses can be constructed and how it can be tested.

So, does light reflect off all surfaces? Let's observe by doing the activity given below. [5-5-ACT, p.120]

The quote above indicates that the textbook might aim students to share their ideas about the result of the experiment before conducting the activity. Also, it gives an opportunity to construct hypotheses before experiment; it was not mentioned explicitly to teach hypothesis testing.

As a summary it can be said that M is not represented well in the 5th-grade science textbook. There are some implicit references to some of the M but there should be explicit explanations about different types of methods in scientific studies in content sections and 5th-grade science textbook should encourage students to use different methods consciously in activity and assessment sections.

4.1.2.1.4. The Representation of Scientific Knowledge in the 5th-Grade Science Textbook.

The references of “scientific knowledge (SK)” were generally found in the 1st and 2nd and 5th units whereas there are no codes in other units. The most repeated code is ‘development of SK’ (f = 8) whereas ‘model’ (f = 2), ‘law’ (f = 1), and ‘theory’ (f = 1) are other codes found in the textbook. The development of SK and theory were mentioned in the same statement as follows.

Scots scientist James Clerk Maxwell proved in 1864 that light is a kind of wave. In 1958, Charles Townes and Arthur Schawlow used Maxwell's discoveries to develop the theory to make light stronger. Two years later, Theodore Maiman, a junior worker at Hughes Aircraft, fired a powerful flashlight wrapped around a ruby crystal rod and invented the laser. The glare of light produced by Maiman was the strongest ever. [5-5-CONT, p.137]

This statement explains the development of SK by giving examples from history of science. Since the theory is given explicitly as a keyword in the text, it can be said that theory, which is one of the types of scientific knowledge, is explicitly included in the textbook. However, the inclusion of the keyword once throughout the textbook does not explain that theory is a type of SK and is related to other types of SK such as models and laws. Therefore, it can be concluded that the textbook does not emphasize the types of SK enough.

4.1.2.1.5. The Representation of Social Certification and Dissemination in the 5th-Grade Science Textbook. All units except the 4th unit include some references to “social certification and dissemination (SCD)” Throughout the textbook ‘dissemination code’ (f = 11) was found more to represent sharing, exhibit and presenting the results with other students. Also, some ‘dissemination channels’ (f = 4) such as science fairs, school newspaper, public network (internet), classroom board, and school exhibitions are mentioned in the textbook to encourage students to share their models, research or findings with other people. The example statements for both of the codes are given below.

Let's write the following articles on the cardboard and post them on the school board. Let's share the solution suggestions for environmental problems with our friends. [5-6-ACT, p.159]

Let's promote our model in areas such as science festivals, school exhibitions, school newspapers and General Network. [5-1-ACT, p.18]

The quotes from the 5th-grade science textbook may indicate that the textbook includes some activities to encourage students to share their solutions or models with other students via different dissemination channels. In addition to those codes, ‘*certification*’ (f = 3), ‘*verification by testing*’ (f = 3), ‘*benefitting works of others*’ (f = 1), and ‘*working with collaboration*’ (f = 1) are other codes created for this category in some of the units. Following excerpt is given for working with collaboration and benefitting works of other codes.

In 1958, Charles Townes and Arthur Schawlow used Maxwell's discoveries to develop the theory to make light stronger. [5-5-CONT, p.138]

The quotation above indicates that the statement explains two scientists working together to develop theory by benefiting another scientist's discoveries. To sum up, it can be said that the 5th-grade science textbook offers many activities for students to share or present their results but there is a need to include statements about how and in which ways scientists share their results with other people in the 5th-grade science textbook to offer some ideas about scientific dissemination and certification process.

4.1.2.1.6. The Representation of Professional Activities in the 5th-Grade Science Textbook.

The textbook includes 'dissemination' (f = 6), 'discussion of ideas' (f = 3), and 'preparing projects/ reports' (f = 2), as one of the "professional activities (PA)". The quotation below presents how students are involved in some of the professional activities in science classrooms.

Let's design a project for an environmental problem in our environment by examining the following. [5-6-ACT, p.159]

What could be the environmental problems we will face in the future if we continue to pollute our environment? Let's discuss the answers to this question with our friends. Let's note the results of the discussion and display them in the class board. [5-6-ACT, p.160]

The 5th-grade science textbook comprises some activities for including students in dissemination ways, preparing projects and reports and conducting discussions with their peers on scientific issues as some of the professional activities. Despite this, professional activities attended by scientists are not included in the textbook. If professional activities that scientists attend are presented to students in the content sections, the students know better which scientific activities the scientists are involved in and thus they establish a link between their own activities and the professional activities that scientists participate in.

4.1.2.1.7. The Representation of Scientific Ethos. Throughout the textbook, no codes of "scientific ethos (SE)" were identified.

4.1.2.1.8. The Representation of Social Values in the 5th-Grade Science Textbook. The 5th-grade science textbook does not give an adequate importance on “social values (SV)” which is one of the social categories of science. There are only 2 codes which are *doing no harm* and *benefit for the environment* as SV in content sections of 3rd and 6th units were detected as follows.

The General Directorate of Nature Conservation and National Parks established a bald ibis production station in Bilecik in order to prevent the decrease in bald ibises and to increase their number again. Since 1989, bald ibises have been taken into cages at stations before the migration period and released again during their reproduction period. [5-6-CONT, p.149]

In the example, a study is being carried out to increase the number of creatures in danger of extinction, and the main purpose of these studies is to protect nature, implicitly is taught to the students. It has not been found in any part of the 5th-grade science textbook that scientific studies should pursue social utility and that living things and nature should not be harmed during scientific studies.

Lastly, there are laboratory safety symbols section before the units. In that section, it is emphasized which rules should be followed in the laboratory. In this way, students can learn that there are some rules they should follow in the labs while conducting a scientific study.

4.1.2.1.9. The Representation of Social Organizations and Interactions in 5th-Grade Science Textbook. Two codes which are *social organizations and institutions* ($f = 2$) and *interactions among organizations* ($f = 4$) were found in just 1st and 6th units as “social organizations and interactions (SOI)”. The codes were mentioned as following:

The European Space Agency (ESA) is developing a spacecraft called Orion (Orion) with the American Aeronautics and Space Administration (NASA) in order to travel to the Moon. ESA is also working with Russia on a vehicle to land on the lunar surface to be used in this project. This landing craft will be used for many jobs, for example searching for water on the Moon. [5-1-CONT, p.23]

The emphasis on the SOI category was detected only in 1st and 6th units. Institutions such as laboratories, schools, universities where scientific studies are conducted are not

mentioned throughout the textbook and the relationship between people working in these institutions is not mentioned.

4.1.2.1.10. The Representation of Financial Systems in 5th Grade Science Textbook. There is only one code which is *launching a product* was found in the 4th unit of the 5th grade science textbook for “financial systems (FS)” category as follows.

Although Clarence Birdseye was not the first to freeze food by bringing to life the idea that she could freeze food in small packages for home use, she was the first to discover and launch frozen foods. [5-4-CONT, p.108]

In this example, the release of a product resulting from a scientific study may be included in the FS. However, there is no emphasis on the need for a budget to carry out scientific studies and where scientists can get the budget they need.

4.1.2.1.11. The Representation of Political Power Structures in 5th-Grade Science Textbook. It is not mentioned in the 5th-grade science textbook what effect “political power structures (PPS)” have on scientific studies. There is only one code which is *international cooperation* for the PPS category as follows.

The European Space Agency (ESA) is developing a spacecraft called Orion (Orion) with the American Aeronautics and Space Administration (NASA) in order to travel to the Moon. ESA is also working with Russia on a vehicle to land on the lunar surface to be used in this project. This landing craft will be used for many jobs, for example searching for water on the Moon. [5-1-CONT, p.23]

An example is given about that different countries can be in a relationship with each other when a scientific study is conducted. However, this example is not enough to teach that PPS are one of the social categories of science.

4.1.2.1.12. Science, Engineering and Entrepreneurship Applications. The science and engineering applications given on the introductory page of the 5th-grade science textbook are mostly considered as engineering studies. It was emphasized that engineers used design cycle steps and scientific research steps in their studies. There is no scientist emphasis. A design step cycle is given on a diagram. When the details are examined in the steps, there

are some emphasized in SP and M. It is seen that they encourage students to use publishing tools such as library, newspaper and magazine to research. At the same time, the desire to choose the most suitable solution among the possible solutions also encourages the student to understand that there is more than one scientific method, but scientific research steps were given step-by-step.

This section is asked to test the selected solution proposal with some practices such as experiment, questionnaire, and observation. However, these practices are called methods in this section. In this section, students are assigned to design a model to solve one of the human problems by being original and using low-cost products. These can be considered as an emphasis on the SV, SE and FS categories. Lastly, students are encouraged to present their models with others via internet, exhibition and science fests. These statements also include some references to SCD and PA categories.

4.1.2.1.13. Summary of the Results of the 5th-Grade Science Textbook. As a summary, when all the subunits in the 5th-grade science textbook were examined, it was seen that the most codes were formed from SP. However, the fact that a great majority of each created in SP is only in the activity and assessment sections reveals the deficiency in the content sections. AV, M and SK which are the epistemic and cognitive categories of science are rarely emphasized throughout the textbook, and the derived codes show that the textbook is not sufficient to teach these categories.

When the social categories are examined, SCD and PA categories are sufficiently included in the activity sections, but the emphasis of these categories in the scientific world is not made in the content sections. Apart from these two categories, other social categories which are SV, SE, SOI, FS, and PPS were found not to be adequately represented in the textbook. Looking at the units, it is seen that the most emphasis is made in the 6th unit. The reason for this may be that it is the unit with the highest number of achievements in the curriculum. Most of the code in the book is explicitly found in the textbook, while a small part is created using implicit references. Lastly, the SEEA section includes some references to NOS, but they are given as design steps rather than scientific process steps and there is only an emphasis on engineers rather than scientists.

4.1.2.2. The Representation of NOS in the 6th-Grade Science Textbook. There are 11 subsections including results of representation of NOS in the 6th-grade science textbook based on AV, SP, M, SK, SCD, PA, SE, SV, SOI, FS, and PPS categories of science. Also, there are 2 subsections including a science, SEEA and summary of the results of the 6th-grade science textbook.

4.1.2.2.1. The Representation of Aims and Values of Science in the 6th-Grade Science Textbook. In the 6th-grade science textbook, the representation of “aims and values (AV)” is not adequately addressed. There are only 4 different codes which are ‘*medical treatment*’, ‘*raising public awareness*’ which are the subcodes of ‘*serving to humanity*’, ‘*empirical adequacy*’ and ‘*critical examination*’ for AV category in the textbook. Medical treatment code was formed from 2nd unit (f = 2), 5th unit (f = 1) and 6th unit (f = 3) by emphasizing scientific works can be used for healthcare both explicitly and implicitly. Following excerpts from the 6th-grade science textbook indicates how textbook portrays the medical treatment code.

Today, these diseases can be easily treated with early diagnosis vaccines have been developed for most of these diseases. Childhood vaccinations protect us from some of these diseases. [6-6-CONT, p.234]

Blood vessels and organ transplants can be performed from one's own body or from another person in order to eliminate health problems related to blood circulation and vessels. But scientists are trying to develop remedies for situations where this is not possible. Synthetic veins produced as a result of these efforts can be successfully transplanted to patients. [6-2-CONT, p.63]

Those excerpts may indicate that the textbook may aim to teach students that scientific studies are used in the diagnosis and treatment of many diseases. However, all of the medical treatment codes were generated from content parts of the textbook. In the activity or assessment parts there are no highlights to encourage students to design scientific works or discuss something for medical treatment. Also, raising public awareness code emphasizing that scientific works or institutions can inform and raise people’s awareness was found once in the 6th unit. In addition to these codes empirical adequacy is repeated once in 1st, 4th and 6th units implicitly like in the following excerpt from 6th-grade science textbook.

As a result of a series of observations made by William Herschel (Vilyim Herchel) on March 13, 1781, it was understood that it was a planet. [6-1-CONT, p.19]

This excerpt indicates that scientific works are based on the series of observations and shows that the scientist has based his claim on data from his observations. Besides, critical examination code was found in 1st and 7th unit for once.

Briefly, it can be said that the textbook represents the AV moderately in content sections. However, it is not represented adequately in the activities, and assessment questions. Some other epistemic and cognitive aims and values of science such as objectivity, novelty and accuracy and some social values like decentralizing power, honesty or equality of intellectual authority could be integrated into content, activities and assessment sections equally to teach epistemic cognitive and social aims and values of science.

4.1.2.2.2. The Representation of Scientific Practices in the 6th-Grade Science Textbook. In the 6th-grade science textbook, there are different practices such ‘data’ (f = 50), ‘scientific explanation’ (f = 47), ‘observation’ (f = 32), ‘experimentation’ (f = 31), ‘inference’ (f = 31), ‘representation’ (f = 27), ‘model’ (f = 26), ‘real world’ (f = 20), ‘research’ (f = 18), ‘prediction’ (f = 17), ‘discussion’ (f = 14), ‘classification’ (f = 10), and ‘comparison’ (f = 8). SP which is the epistemic and cognitive category of is included more in the 6th-grade science textbook when it compared with other categories of science. In the activity and assessment sections it is aimed students to use many practices in investigations. In the following excerpt, prediction, experimentation, data, real world and scientific explanations are represented.

How might our tongue perceive taste impulses? We sometimes have difficulty enjoying the food we eat. I wonder what the reason for this is. Do the following experiment to find answers to these questions... ...Note in your notebook whether you can detect the taste of sugar when your tongue is dry... ...Did you taste the sugar while your tongue was dry or wet? What is required for your tongue to receive taste warnings? [6-6-ACT, p.214]

According to this example, it can be said that textbook includes experiments related to real world and students use many practices for the same investigation to make a prediction, collect data and explain their results.

Merve was watching the electric cables on which the birds lay from the windows of their house. "I wonder what kind of material electrical cables could be made of?" she wondered. It had a thick, threadlike appearance. "They can't be a rope," she thought. But he still wasn't sure. How would you like to try to answer the question Merve is curious about by doing the following experiment?...
 ...Connect these test leads, named A and B, to metal teaspoons, plastic spoons, porcelain spoons and wooden spoons respectively, and observe whether the bulb gives light...
 ...Write down your observations in your notebook...What substances did the bulbs light when you touch the test leads in your circuit? How many groups would you classify the materials you use in your circuit according to whether they conduct electricity or not? [6-7-ACT, p.247]

Activity stated above includes connection between real world and investigation. Also, students are encouraged to do experiment then. They explain the results of the investigation and classify some materials based on their observations and data they write down their notebook.

When classifying moving entities as fast and slow, you make your comparison by looking at the time that these entities took equal paths. Let's observe this by doing an activity...
 ...As soon as you hit the soccer ball with your foot, a friend of yours starts the stopwatch and measure how long it takes to get between the dots. Repeat your measurements by applying different forces to the ball...
 ...Create a chart like the one below and record the measurement values in this chart. [6-3-ACT, p.101]

At above, students are assigned to conduct experiments and take a note their measurements based on their observations and represent their data on the table to explain results. Most of the codes mentioned above were found in the activity sections of the textbook. Inference code generally was generated from assessment sections because in that sections there are many multiple-choice questions and open-ended questions which students use some existed data or model to make an inference to find correct answer or explanation.

Shortly, 6th-grade science textbook includes many practices. Students are made use of many scientific practices together in the formation of scientific knowledge. However, content that answer questions such as what scientific practices are, how scientists use

scientific practices, or what is the link between scientific practices should be included in the content sections of the textbook.

4.1.2.2.3. The Representation of Methods and Methodological Rules in the 6th-Grade Science Textbook. 6th-grade science textbook includes many references to “methods and methodological rules (M)”. ‘*Manipulative testing*’ (f = 21), ‘*hypothesis construction*’ (f = 12) and ‘*hypothesis testing*’ (f = 12) are the most repeated codes in the textbook to represent M. These codes were generated from implicit references because in the activities or content sections hypothesis does not mentioned explicitly. Following excerpt includes references to hypothesis construction and hypothesis testing implicitly.

In the picture to the left, would the swing move if another force equal to and opposite to the applied force acted at the same time? Observe the answer to the above question by doing the "Equal and Opposite Forces" activity. [6-3-ACT, p.92]

Even though textbook does not mention hypothesis construction before activities and testing hypothesis explicitly by explaining the word of “hypothesis” at the beginning of some activity’s students predict the asking question and to answer the question and check their predictions they do experiments, create model or make observations.

Also, manipulative testing code was generated both explicit and implicit statements. Dependent ‘*variables*’, independent variables were mentioned in the textbook in the some of the experiments including manipulative testing. However, in most of the activities the textbook does not explicitly refer to manipulate variables and say that this experiment includes manipulative testing.

With the help of identical heaters, heat the water in beakers for equal times. Measure the temperatures of the waters with a thermometer and note them in your notebook. Put each of the spoons in a beaker and cook for 5 min. and wait. 5 minutes. At the end, touch the spoons one by one and observe their temperature. Write down your observations in your notebook. [6-4-ACT, p.140]

Given excerpt from one of the activities in the 6th-grade science textbook implicitly shows that students change variable like types of the matter to observe change of heat which is the dependent variable. Also, there is no observation activities as a non-manipulative

testing because in most of the activities or experiments textbook mentions observation by saying that “observe the change”, “observe what happened” etc. In addition to these codes, there are some other codes for M category such as ‘*using different methods*’ (f = 2), ‘*using different materials*’ (f = 5), ‘*scientific research process*’ (f = 4) and ‘*different branch of science*’ (f = 2). Although the experiments or creating models are given step by step like cookbook at the end of the some of the activities or projects students are encouraged to use different materials or different methods by using scientific research process to redesign what they did as following.

Create different design models by using scientific research processes by imagining different materials other than the materials you use in your project.
[6-4-ACT, p.120]

These highlights can contribute students to understand different materials can be used but it also borders students by referring scientific research process which is given at the beginning of the textbook. Besides, textbook includes different branch of science like acoustics which is one of the branches of science that studies the properties of sounds. To sum up, it can be said that some of the methods are represented well in the textbook but still there is a need to integrate different methods in science and activities that encourage students to discuss a range of relevant methods for designing appropriate investigations.

4.1.2.2.4. The Representation of Scientific Knowledge in the 6th-Grade Science Textbook.

The “scientific knowledge (SK)” which is one of the categories of science is represented in the 6th-grade science textbook with ‘*development of SK*’ (f = 5), ‘*model*’ (f = 16), ‘*tentativeness*’ (f = 1) and ‘*predictable knowledge*’ (f = 1) codes. Development of SK is mentioned in textbook as following.

The first scientist to study electricity in detail is Benjamin Franklin. He showed in 1752 that lightning is a form of electricity. Later, he developed a tool called lightning rod with his studies. This vehicle ensures that the lightning is transmitted safely to the ground. [6-7-CONT, p.250]

This example from the history of science shows that the scientist discovered that lightning was a form of electricity before developing the lightning rod. He invented the lightning rod as a result of the development of the knowledge he discovered. Thanks to such

true stories, students can gain insight into the development of a scientific knowledge. Development of SK was generally found in the content sections so some references to this code can be integrated in activity and assessment sections of textbook.

There are some highlights models which is one of the types of the SK in the textbook. The textbook generally aims students to use existed models or design models to explain scientific phenomena.

Explain the structure and shape of the ear, which is our hearing organ, using its mirror image and the model in your classroom. [6-6-ACT, p.219]

Do the following activity to better understand how the natural phenomena that occur when the Earth and the Moon orbit the Sun occur. Purpose: To provide a three-dimensional representation of the solar and lunar eclipses so that students can better comprehend. Observing the solar and lunar eclipses using models. [6-1-ACT, p.30]

Examples from 6th-grade science textbook given above may indicate that students can use existed model to explain something and design their own models to comprehend abstract science topic better. To sum up, it can be said that even though there are some references to SK in the textbook such as development of SK and models it fails to highlight the interactions among the types of SK such as theory, law, and model (TLM).

4.1.2.2.5. The Representation of Social Certification and Dissemination in the 6th-Grade Science Textbook. “Social certification and dissemination (SCD)” is included in most of the activity sections in the 6th-grade science textbook. ‘*Dissemination*’ (f = 24) and ‘*dissemination channels*’ (f = 12) are the most repeated and well represented codes in the textbook. Following quotations from the 6th-grade science textbook may indicate how textbook represents the dissemination and its channels under SCD category.

Check out the adjacent newspaper article on organ donation and transplantation. [6-6-ACT, p.39]

Search from sources such internet, encyclopedia, etc. about what causes heat losses in buildings. Share the slide show you will prepare with the results of your research with your friends. [6-4-ACT, p.143]

These excerpts may show that students can know in which channels they can find information about scientific issues or topics. Also, they can prepare presentations to share their studies with their peers with the help of the activities in the 6th grade science textbook. Also, there are some other codes such as ‘*certification*’ (f = 3), ‘*working with others*’ (f = 2), ‘*meeting/conferences*’ (f = 2), ‘*verification by repetition*’ (f = 2) and ‘*evaluation*’ (f = 1) to talk about the SCD category. Briefly, it can be said that SCD category generally is represented with dissemination and dissemination channels codes in generally activity sections of the 6th-grade science textbook. Even though there are some other references to SCD they are not enough and need to be integrated in content and assessment sections of textbook more.

4.1.2.2.6. The Representation of Professional Activities in the 6th-Grade Science Textbook.

The “professional activities (PA)” are generally revolving in the activity sections of the 6th-grade science textbook. Except 3rd unit other units include PA references throughout the textbook. ‘*Dissemination*’ code (f = 18) has been consistently repeated throughout the book. As a professional activity in many activities, it is aimed that students share their work with their friends, present and exhibit them on different platforms. The following statements from 6th grade science textbook encourage students to disseminate their works.

Present the results of your research on the role of enzymes in chemical digestion to your classmates. [6-2-ACT, p.49]

Prepare a poster that will raise awareness about unconscious drug use. You can design your poster on file paper or a cardboard and display it on the board. [6-6-ACT, p.237]

These examples may indicate that students do their own professional activities like a little scientist. ‘*Working with others*’ (f = 9) is another code that aims students to work in a group and their peers in most of the activities in the 6th grade science textbook. ‘*Discussion of ideas*’ (f = 8) code was generated from the statements promote students to discuss their results of research or work. One of the excerpts for this code is below.

Search where sound insulation may be needed more from sources like internet, encyclopedia, etc. Discuss the results of your research with your friends and write them down in your notebook. [6-5-ACT, p.186]

This excerpt may indicate that students should be able to create a discussion environment as a professional activity by sharing the results after doing research. With these activities, it can be aimed that students reach an opinion as a result of discussion.

Besides, there are some other codes for PA such as '*preparing projects/reports*' (f = 7), '*the role of the scientists*' (f = 7) and '*participating in science fest*' (f = 7). In most of the activities students are assigned to prepare projects or reports with respects to results of their research. Also, they are encouraged to participate science fests to exhibit their models and results of their studies as one of the professional activities. Also, the following excerpt from one of the lives of the scientist in the content section of the textbook includes the role of the scientist.

Karl Landsteiner is an immunologist and pathologist...With his studies, he found the main blood groups and improved the blood group system, making blood transfusion a simple process. Landsteiner, who received the Nobel Prize in Medicine in 1930 with this work, found the Rh protein in 1940 and named the blood groups as Rh (+) and Rh (-). [6-2-CONT, p.63]

This excerpt may trigger students to think about the roles of the scientist and taking Nobel Prize as a result of their studies. In addition to these codes '*peer review*' was placed under PA category and it was met once throughout the 6th-grade science textbook. Briefly, it can be said that PA is well represented in the activity sections of 6th-grade science textbook but still there is a need to integrate professional activities that scientist does more in content sections.

4.1.2.2.7. The Representation of Scientific Ethos in the 6th-Grade Science Textbook.

Throughout the textbook, 4 code which is '*genuine work*' (f = 1), '*animal care*' (f = 1), '*respect to environment*' (f = 1), and '*rules in lab*' (f = 4) for "scientific ethos (SE)" were identified in the activity sections and at the beginning of the textbook. Genuine code was formed from the assignment that students create unique, original and individual poster for organ donation campaign. Besides, immediately after the contents section of the textbook, there is a section called laboratory safety in the science course. In this section, what students should pay attention to and the rules to follow while doing a scientific study in the laboratory are given as following.

...When you are done, wash the materials you used in the experiment and your hands with soap and plenty of water...Wear apron to protect yourself from any accidents that may occur during the event. [6-LS-p.14]

At the same time, warnings were made not to harm plants and animals during scientific studies as following.

Do not harm animals. When finished, wash your hands with soap and water. Do not harm plants. Never eat the herbs you use, even if they are foodstuffs. Replant the solid ones of the remaining plants into the soil. [6-LS-p.14]

Even though there are explicit reference to scientific ethos at the beginning of the textbook it is not enough to teach SE because the student may not read the beginning of the textbook. Hence, these warnings can be reminded and included some activities throughout the textbook to teach SE.

4.1.2.2.8. The Representation of Social Values in the 6th-Grade Science Textbook. Two different values are represented for “social values (SV)” category in the 6th-grade science textbook. ‘*Social utility*’ (f = 5) and ‘*moral and national values*’ (f = 1) are the codes generated under SV. One of the statements about the social utility as a social value is below.

Prof. Dr. Aziz Sancar provides important contributions to its society, country and all humanity with its works. [6-6-CONT, p.234]

This excerpt explicitly states that Prof. Dr. Aziz Sancar who is one of the famous Turkish scientists contributes to society by his scientific works. Although some content and activity sections do not explicitly emphasize that scientists pay regard social utility while doing scientific investigations, they implicitly include the contribution and help of some science topics like sound insulation, to people.

Lastly, moral and national values were mentioned explicitly by emphasizing the scientific works of the Turkish Green Crescent Society (Yeşilay) to protect the society from harmful habits. To sum up, the 6th grade science textbook does not include adequate references to SV even though there are some explicit and implicit statements about some of the SV. It was found that respect for environment, animal care, doing no harm to people, honesty, intellectual property and other social values are not included in any sections of the

science textbooks. ‘*Respect to environment*’ (f = 1) and ‘*animal care*’ (f = 1) codes also were formed for this category from the same excerpts given SE.

4.1.2.2.9. The Representation of Social Organizations and Interactions in the 6th-Grade Science Textbook. The references of “social organizations and interactions (SOI)” were found in the 4th and 6th units. ‘*Scientific organizations and foundations*’ code were formed because some organizations such as TÜBİTAK (The Scientific and Technological Research Council of Turkey) and Yeşilay (Turkish Green Crescent Society) were mentioned for once in the textbook and also ‘*laboratory*’ and ‘*hospitals*’ were mentioned once as a SOI. Also, ‘*communication among institutions*’ was highlighted with following statement.

...The coordination center is in contact with all hospitals...While the organ sent by the coordination center is still on its way, the doctors at the tissue and organ transplantation center prepare the patient for the operation... [6-6-CONT, p.239]

This statement may teach student that while doing scientific work like transplantation social institutions such as hospitals and coordination centers communicate with each other. However, those examples are not adequate to teach types of the social organizations, communication of employees in these organizations with each other and communications among institutions to generate scientific knowledge.

4.1.2.2.10. The Representation of Financial Systems in the 6th-Grade Science Textbook. In the 6th-grade science textbook, it is not clearly stated that there is a need budget for scientific works. However, some financial issues like ‘*commercialization*’ and ‘*scholarship*’ were mentioned once in the textbook. For example, scholarship is mentioned that Aziz Sancar who is the scientist went to America with a TUBITAK scholarship for continue his scientific works. Even though given examples in the textbooks are well structured and represent FS well the frequency and diversity of the statements related to FS are not enough to teach FS as a one of the categories of science. There is a need to design some activities and also some contents for that category.

4.1.2.2.11. The Representation of Political Power Structures in the 6th-Grade Science Textbook. There are very limited references to “political power structures (PPS)” throughout the 6th-grade science textbook. ‘*International meeting*’ (f = 2), ‘*government laws*’ (f = 1) and

‘*gender free*’ (f = 1) are the generated codes for this category. International meeting was generated from following excerpts in the 6th-grade science textbook.

The International Astronomical Union (IAU) removed Pluto from the planetary class and included it in the "Dwarf Planet" at its meeting in Prague on August 24, 2006. Scientists attending the meeting redefined the concept of the planet. [6-1-CONT, p.20]

The International Conference on Weights and Measures meets in Paris every four years. Our country is also a member of this conference. [6-4-CONT, p.125]

These statements from the content sections of the 6th-grade science textbook may aim to teach students that scientific works can be discussed by scientists in international conferences or meetings to present common and plausible results. In this way students can think about the effect of the international politics on science. Also, government law code was created from the text emphasizing scientific works like organ transplantation were assured by Turkish governmental law.

Lastly, it can be said that there is no explicit or implicit reference to whether belief, race, and gender have an impact on the development of scientific knowledge and scientific works. However, the inventor Mrs. Josephine Cochrane, mentioned at the end of 7th unit, may aim to implicitly teach students that scientific studies can be done not only by men but also by women.

4.1.2.2.12. Science, Engineering and Entrepreneurship Applications. This section is given in the 6th-grade textbook before starting the units. Later, in the SEEA sections in each unit, orientation was made to this page without explaining each step again and again. This section was divided into two parts which are scientific research process and engineering design process. In the scientific research process part serving to humanity and accuracy codes were generated for AV. For the SP this section encourages students to do research and conduct experiment to produce scientific knowledge. Also, representation code was generated from the statement emphasized that students could organize their observations about the experiment using graphs, tables and diagrams.

For the M hypothesis construction and hypothesis testing codes were generated. Hypothesis construction is explained as writing guessing sentences for the solution of the problem. Also, in this section only hypothesis testing was mentioned as a method by mentioning “you should test whether your hypothesis is correct by experimenting” this may cause students to be misinformed that there is only one scientific method. There are also some references to SCD and PA which are dissemination, dissemination channels and participating in science fest. The link between scientist and students were constructed in that part even though it is lacking in the units of the textbook.

Scientists share their experimental results with other people. Tell your friends about the results of your experiment or research. Make your presentation about your work by participating in your school's science festival. You can make this presentation by preparing a newspaper, internet, television advertisement or by making a short film. [6-SEEA-p.12]

Statement above shows how scientist share their results and encourage students to act like scientist by sharing results of their studies with different channels and participating in science fests. Even though this connection is extremely good it is not enough to mentioned one time throughout the textbook. These types of statements should be integrated in each unit of the textbook. In the engineering design process part serving to humanity and empirical adequacy code was found for AV category. For the empirical adequacy it stated that engineers use scientific facts when planning. Also, observation and model are mentioned as a SP in that section. The using different methods code was generated from the statement emphasizing that there are different ways to solve a problem. Also, development of SK is the code under the SK mentioning development of presented models. For the SCD, repetitive testing, dissemination, and dissemination channels were mentioned. Lastly, need for money while doing a study is mentioned by stating that while using the engineering design cycle you should find faster, better and cheaper ways.

4.1.2.2.13. Summary of the Results of the 6th-Grade Science Textbook. To sum up the results of the 6th-grade science textbook it can be said that NOS emphasis has been attempted in the 6th-grade science textbook. However, under each category there are incomplete or misrepresented emphasizes. Looking at the code numbers and code names, it is seen that SP is well represented in the assessment sections of the 6th-grade science textbook. However, the fact that all the representations are in activity and assessment shows that there is a need

in the content parts to make a connection between scientists and students. AV, SK and M categories include many references but there is a need to integrate more content to explain and teach those categories to students.

When comparing epistemic, cognitive categories and social categories, it can be said that social categories have less emphasis in the 6th-grade science textbook. However, although SCD and PA are social categories, they are well represented in the activity and SEEA sections of the textbook. However, the references given in the science, engineering and entrepreneurship applications need to be repeated and diversified in units throughout the textbook. SE and SV are the categories has less emphasized. The most explicit emphasis on these codes is placed in LSS. FS, SOI and PPS are generally represented in the content sections. While most of the codes extracted from the book are given as explicit, implicit accents are also determined.

4.1.2.3. The Representation of NOS in the 7th-Grade Science Textbook. There are 11 subsections including results of representation of NOS in the 7th-grade science textbook based on AV, SP, M, SK, SCD, PA, SE, SV, SOI, FS, and PPS categories of science. Also, there are 2 subsections including SEEA, and summary of the results of the 7th-grade science textbook.

4.1.2.3.1. The Representation of Aims and Values of Science in the 7th-Grade Science Textbook. The 7th-grade science textbook is lacking the references to “aims and values (AV)” of science. In the textbook, only 2 references of AV were found. ‘*Ease of life*’ and ‘*medical treatment*’ are the subcodes of the ‘*serving to humanity*’.

The advancement of science and technology has brought many innovations in the field of medicine. One of them is the in vitro fertilization method...
...This method is one of the possibilities that technology and science offer to humanity... [7-6-CONT, p.199]

As can be seen from this quote, it is explained with an example in the textbook that science contributes to humanity. However, AV category is not mentioned in the rest of the textbook. This shows that AV, which is one of the categories of science, is not sufficiently represented in the 7th-grade science textbook.

4.1.2.3.2. The Representation of Scientific Practices in the 7th-Grade Science Textbook. In the 7th-grade science textbook, there are different “scientific practices (SP)” such ‘*observation*’ (f = 32), ‘*scientific explanation*’ (f = 23), ‘*discussion*’ (f = 28), ‘*representation*’ (f = 18), ‘*data*’ (f = 17), ‘*real world*’ (f = 9), ‘*model*’ (f = 26), ‘*research*’ (f = 8), ‘*classification*’ (f = 5), ‘*experimentation*’ (f = 5), ‘*comparison*’ (f = 5), ‘*prediction*’ (f = 4), ‘*inference*’ (f = 4) and ‘*model*’ (f = 2).

SP category is mostly found in the activity sections of the science textbooks. The textbook does not mention that scientists can use some practices to reach scientific knowledge, but it includes many activities for students to use SP. In the textbook, the word observation is sometimes used to examine things by using a microscope, but it is often used to observe the result of every experimental activity. Also, most of the practices are used together to reach scientific knowledge. For example, the example below includes data, observation, discussion, scientific explanation and representation codes as one of the SPs to reach SK.

...Weigh the stones sequentially in equal arm scales. Note the value you have obtained in the table below. Tie ropes to the stones and hang them on the dynamometer. Note the values you observed in the dynamometer in the table...
What Did You Observe? Are the values you measured with dynamometer and equal arm scale the same? Why?
 -What do the values you measure with dynamometer and equal arm scale mean?
 Discuss. [7-3-ACT, p.72]

With this activity, the student is asked to weigh different items and note the measurement results on a table. In this way, the student may learn to represent the obtained data on a table. Later, the student is asked to make observations during the weighing process and to explain and discuss the results according to the observation results. The 7th-grade science textbook offers diversity to the students about the use of different practices together.

Apart from that, although the textbook sometimes includes some practices, it does not give details about them. For example, the 7th-grade science textbook includes a classification example in some units of the textbook and sometimes asks students to classify something. However, these activities are generally like sorting activities.

Substances are classified according to the type, appearance and number of atoms and molecules in their structure. [7-4-CONT, p.114]

Give examples of various mixtures from daily life. Classify them as homogeneous and heterogeneous. [7-4-ACT, p.127]

One of the examples above that items are classified according to some properties. In the other, students were asked to classify some mixtures. However, these activities are not intended to teach the predictive features of the classification. These activities are as sorting activities. Hence, the activities related to classification can be revised. Briefly, it can be said that 7th-grade science textbook includes sort of practices in it. However, almost all are found in the activity sections. Hence, there is a need to integrate SPs in content sections more to teach what SPs are and how scientists use them to reach SK.

4.1.2.3.3. The Representation of Methods and Methodological Rules in the 7th-Grade Science Textbook. Although there is some emphasis on “methods and methodological rules (M)” in the textbook, there is no adequate emphasis that there are different branches of science and that these branches can use different methods depending on the field in scientific studies. Some codes have been created for this category. ‘*Branch of science*’, and ‘*using tools*’ (f = 5) are one of the codes under M category.

Astronomy is the branch of science that studies the states and motions of celestial bodies in space. [7-1-CONT, p.21]

During these studies, astronomers make use of tools called telescopes. [7-1-CONT, p.25]

The examples taken from the textbook indicate that the textbook explains one of the branches of science. However, in the other units of the textbook, a different branch of science was not emphasized and the similarities and differences between these branches of science were not discussed. In the other excerpt, it was clearly stated that a telescope was used when conducting a scientific study. However, it is not emphasized that in some branches of science, telescopes can be used, and some other tools can be used in different branches.

There are also some other codes which are ‘*construction of hypothesis*’ (f = 9), ‘*hypothesis testing*’ (f = 11), ‘*manipulative testing*’ (f = 12) and ‘*variables*’ (f = 2). Among

these codes, variables are found explicitly in the textbook, but all of the others are implicitly found in the textbook. Even though the word hypothesis is never used during the activities, the student is expected to answer a question and then do the activity and discover the questions.

Does the magnitude of the kinetic energy of an object change? Which variables affect kinetic energy? To find out, do the following activity. [7-3-ACT, p.25]

In the example, it is stated implicitly that students are expected to identify a hypothesis and then test that hypothesis. At the same time, it is clearly stated that they need to make an experiment by changing the variables.

What the variable means is explained clearly.

While conducting an experiment, certain values are kept constant, and others are checked. Variables changed during the experiment are called independent variables. Variables that change depending on the independent variables are called dependent variables. Variables whose amount does not change are called variables that are controlled or kept constant. [7-4-ACT, p.129]

There are activities that involve students learning the concept of variables and reaching a conclusion by changing variables in their experimental setup. However, all observation, modeling and experimenting activities in the textbook are presented in the form of a cookbook. There was only one activity that the students would choose their own method. This activity has direction as following.

Select the appropriate method that can be used to separate the mixtures by doing the following activity. [7-4-ACT, p.133]

It is aimed for the student to choose the most correct method among the given methods. However, there should be more activities teaching students that they can use different methods to reach a result and explain which method they choose and why. In short, although the 7th-grade science textbook contains some emphasis on M, these are not enough to teach M explicitly and accurately.

4.1.2.3.4. The Representation of Scientific Knowledge in the 7th-Grade Science Textbook.

Although the 7th-grade science textbook could not emphasize the connection among the

forms of “scientific knowledge (SK)”, it provides many examples from the history of science to teach development of SK. In almost all units of the science textbook, an example from the history of science is given at least once and how scientific knowledge has developed with technological advancements is explained. Some of the examples to which the ‘*development of SK*’ (f =13) code belongs is as follows.

The first telescope was discovered by accident, by Hans Lippershey, a Dutch optician. Later, in 1609, Galileo (Galilei) developed this telescope and used it for sky observations. [7-1-CONT, p.27]

Robert Hooke, who lived in the same century, observed the structures in bottle cork with the microscope he developed. Hooke named the structures he observed in the mushroom “*celula*”, meaning “cavity” or “cell”. Thanks to the developing technology, it has been understood after years that these structures, which Hooke has examined, are the cell walls with dried inside. For this reason, it is accepted that the existence of the cell was first put forward by Hooke. [7-2-CONT, p.48]

Investigate the opinions put forward about the structure of the cell from past to present from various sources. Discuss them with your friends by relating them to technological advances. [7-2-ACT, p.47]

As seen above, examples from the history of science related to the development of scientific knowledge over time are presented. After this information given in the content sections, a research task was given in which students could examine the development of scientific knowledge. Besides, there are some codes presenting the nature of SK. They are ‘*credible*’ (f =2), ‘*falsifiable*’ (f =1), and ‘*tentative*’ (f =2) *nature of SK*. Tentative nature of SK is explained explicitly with the following example in the 7th grade science textbook.

With the advancement of technology, microscopes have been developed and the cell has been better studied. As a result, new information about the cell has begun to be acquired. With the development of the light microscope, it was discovered that the cell was not a vacuum, but that there were some structures in it. Thus, it was understood that scientific knowledge is not precise and can change and develop. [7-2-CONT, p.48]

As can be seen from the example, the 7th-grade textbook emphasizes that SK is not precise and can change and develop. The 7th-grade science textbook also emphasizes that some of the products have been produced as a result of the space research. In addition, the falsifiability of SK over time is explained with the example below.

In ancient times, people believed that the Earth was made up of four different elements: earth, air, fire and water. As a result of later studies, it was understood that these substances were not elements and dozens of new elements were discovered. [7-4-CONT, p.115]

The textbook emphasizes that scientific knowledge can develop over time as well as falsifiable. In addition, '*law*' (f = 2) and '*model*' (2) which are the forms of SK are mentioned in the textbook as following.

As the number of batteries in the electrical circuit increases, the voltage between the ends of the bulb increases. As the voltage increases, the electric current also increases. However, the voltage / current intensity ratio remains constant. This is known as Ohm's Law. This law was found by George Simon Ohm. [7-7-CONT, p.231]

Although the word law is included in the textbook, it is not explained exactly what the law is and how it relates to other forms of SK.

In short, although the 7th-grade science textbook could not explain the theory, law and model and their relationship with each other very well, it provided a sufficient number of examples from the history of science about how scientific knowledge developed.

4.1.2.3.5. The Representation of Social Certification and Dissemination in the 7th-Grade Science Textbook. The category of “social certification and dissemination (SCD)” is not sufficiently represented in the 7th-grade science textbook. When all units were examined, only '*dissemination*' (f = 7) code was created. There is no information on how scientific knowledge is accepted and how it is spread. However, However, several activities in the textbook encourage students to share, present and exhibit their results as follow.

Express your design with a drawing. Then, if the possibilities allow, create a three-dimensional model. Display your designed product at the science festival at the end of the year. [7-5-ACT, p.184]

Observe the development process of this plant or animal. Report your observations as follows and present them to your friends. [7-6-ACT, p.215]

As seen in the examples, there are activities for students to share their results and products. However, information on social certification criteria and channels through which scientific knowledge is disseminated is limited.

4.1.2.3.6. The Representation of Professional Activities in the 7th-Grade Science Textbook.

The 7th-grade science textbook includes some reference to “professional activities (PA)”. ‘*Working together*’ (f = 5), ‘*participating in science fest*’ (f = 5), ‘*discussion of ideas*’ (f = 3), ‘*dissemination*’ (f = 6), and ‘*making report*’ (f = 1), are the professional activities which are mentioned in the textbook. Working together is mentioned in both activity and content sections of the textbook as follows.

By cooperating with your friends, you can ensure waste control in your immediate environment. You can use the examples given below for this. [7-4-ACT, p.141]

In addition, thanks to this observatory, scientists will be able to study much more up-to-date and hot topics with international observatories. [7-1-CONT, p.26]

The textbook not only encourages students to work together, but also emphasizes that scientists work with different institutions.

You can exhibit your designed product at the end of the year science festival. [7-4-ACT, p.139]

There are also activities that encourage students to present their products and to participate in the science festival as a professional activity. Besides, many studies of scientists are included in the textbook to show the role of the scientists. In this way, ‘*role of the scientists*’ (f = 6) is emphasized in many parts of the textbook. In these parts, the characteristics of scientists are also mentioned. Some of the examples from science textbook are below.

Scientists tries to find the hidden facts in this area by doing a lot of research on planets, stars and other celestial bodies. [7-1-CONT, p.19]

In addition, today, three Turkish scientists have discovered a new planet by overcoming all difficulties with patience and determination... [7-1-CONT, p.28]

Scientists have researched for many years and continued their studies with patience and determination. By working without giving up in the face of failure, their determination paid off. [7-2-CONT, p.49]

As can be seen in the examples above, contents that enable students to get to know scientists are presented in the 7th-grade science textbook. Besides, Turkish-Islamic scientists, European scientists and some other scientists who carry out their studies today are mentioned in the textbook. In short, the textbook represented the PA category well in both the activity and content sections. However, other professional activities of scientists such as participating in conferences, and peer review can still be mentioned in the textbook.

4.1.2.3.7. The Representation of Scientific Ethos in the 7th-Grade Science Textbook. The representation of the “scientific ethos (SE)” category is lacking in the 7th-grade science textbook. Only two codes were identified throughout the units which are ‘*universalism*’ and ‘*studies to protect environment*’. The highlights for this category are not enough to teach scientific ethos.

4.1.2.3.8. The Representation of Social Values in the 7th-Grade Science Textbook. Only 4 codes were created within the “social values (SV)” category which are ‘*studies to protect environment*’ and ‘*social utility*’.

The statement that one should not harm the environment while conducting a scientific study is not included in the textbook whereas there are activities to raise awareness among students on issues such as recycling, and space pollution as follows.

The Swiss Federal Institute of Technology Space Center in Lausanne has developed a project to clean up some of the space garbage in Earth's orbit. Within the scope of this project, it is aimed to collect large wastes such as fuel tanks, satellite parts and satellites that have completed their missions by scavenger spacecraft. [7-1-CONT, p.24]

Apart from this, there are laboratory safety symbols section before the units. In that section, it is emphasized which rules should be followed in the laboratory. In this way, students can learn that there are some rules they should follow in the labs while conducting a scientific study. However, these rules may also need to be emphasized within the units.

4.1.2.3.9. The Representation of Social Organizations and Interactions in 7th-Grade Science Textbook. It can be said that the “social organizations and interactions (SOI)” category is represented in the textbook with many different examples. Throughout the textbook, many different organizations in which scientific studies are carried out are mentioned. They are ‘social organizations (such as TÜBİTAK, NASA)’ (f = 4), ‘observatory’ (f = 2), ‘laboratory’ (f = 2), ‘hospital’ (f = 1), ‘school’ (f = 1), ‘municipality’ (f = 1), ‘factory’ (f = 1), ‘space center’ (f = 1), ‘international space station’ (f = 1). The examples from the laboratory, observatory, international space station and hospital are presented below.

By creating non-gravity laboratory environments in different countries around the world, the effects of the non-gravity environment on human, animal health and plant growth are examined. [7-3-CONT, p.71]

Observatory (observatory); They are places where large telescopes are located, and astronomers observe. [7-1-CONT, p.27]

The "International Space Station" built by 16 countries in 1998 continues its mission. Space exploration can be done more easily thanks to space stations. [7-1-CONT, p.22]

Between 2015 and 2017, a study was conducted in the Gynecology and Obstetrics Clinic of Zeynep Kamil Obstetrics and Pediatrics Training and Research Hospital. [7-6-CONT, p.24]

Although the social institutions and their relations are not explained in detail, it is possible to find different organizations in which scientific studies are carried out in many parts of the textbook. When compared with other social categories, it can be said that SOI category well represented in the science textbook.

4.1.2.3.10. The Representation of Financial Systems in the 7th-Grade Science Textbook. The “financial system (FS)” is hardly ever represented in the 7th grade science textbook. ‘Need for money’ (f = 1) and ‘national economy’ (f = 2) codes were created for the FS category. In the examples including these codes, how financial systems affect science is not explained clearly and in detail. However, it is explained with the following example that scientific studies contribute to the country's economy.

Research the contribution of recycling facilities to the economy from various sources. Discuss this issue with your friends using the research results and the information given above. [7-4-ACT, p.139]

The reference to this category is not adequate to teach financial systems to students.

4.1.2.3.11. The Representation of Political Power Structures in the 7th-Grade Science Textbook. For the PPS category there is only one code which is found twice throughout the textbook. The example from the '*international collaboration*' (f = 2) code is as follow.

SOLAR-ERA.NET Cofund is a project in which TUBITAK also participates within the scope of the European Union Horizon 2020 Program. It aims to establish research and development partnerships in the studies conducted by the industry regarding the generation of electricity from solar energy among European countries. In addition, it aims to increase industrial practices in generating electricity from solar energy. Within the scope of SOLAR-ERA.NET Cofund, an international call was made to support solar energy R&D projects. [7-5-CONT, p.162]

As a summary, it is possible to say that PPS is not sufficiently emphasized in the 7th-grade science textbook and some references to PPS should be included in both activity and content sections.

4.1.2.3.12. Science, Engineering and Entrepreneurship Applications. There is a section called science, engineering, and entrepreneurship applications (SEEA) at the introduction of the 7th-grade science textbook. In this section, the definition of science is mentioned as follows.

Science is based on observations and experiments. Determining a problem and putting forward a theory occurs at the end of a scientific process [7-SEEA-p.12]

Although there is an emphasis on theory, which is a type of scientific knowledge, at the end of scientific studies, there is no emphasis on other forms of SK. In this section, scientific research processes are explained through a visual. In this visual, the steps of inquiry process which are determining the problem, making observations, forming a

hypothesis, testing the hypothesis, analyzing, interpretation, retesting and forming a theory are given.

In some of the activities in the units in the textbook, these steps are encouraged to be used and students are directed to this page. However, methods and practices do not seem to be different from each other here. The perception that students must establish a hypothesis for each study and test it may occur in the minds of the students. In the following, there are activities on what students can do at each inquiry stage. In there, the students are required to do research and design a model which are one of the SPs. In addition, students were asked to represent the data they obtained in different ways such as tables and graphics. Emphasis on the AV and SV categories are in this section. It is expressed as follows.

When science and engineering applications come together, very important discoveries for humanity emerge. In our age, human needs are diversifying, and new engineering branches are emerging accordingly. [7-SEEA-p.13]

From here, students can learn that the aims and value of science is to serve humanity. In addition to the emphasis on scientists, students are also encouraged to make studies that will contribute to humanity as follow.

It is not only the job of scientists and engineers to produce solutions to the problems encountered in daily life. You can also develop designs to solve various problems by using your own knowledge and experience at all ages. [7-SEEA-p.14]

There is a lot of emphasis on the SCD and PA categories. Collaboration is emphasized in many stages of the work and students were asked to share their work and products with their friends. Students were asked to present their works on television, newspapers, and the internet and they were encouraged to participate in the science festival. Although there is no more explicit emphasis on FS and PPS, students are required to make a cost plan while doing their studies in this section. Thus, it may be aimed to teach students that money is needed while conducting a scientific study. In addition, a photography of a Muslim female scientist is given in this section. In this section, Turkish Scientist Aziz Sancar is introduced as follows.

Aziz Sancar, who wants to contribute to science, went to Johns Hopkins (Cans Hapkins) Institute with a TÜBİTAK scholarship to study biochemistry
Sancar faced various difficulties during his studies. However, in the face of all this, he did not give up and was patient...
 ...Sancar was awarded the Nobel Prize in Chemistry in 2015 for his work in the field of DNA repair. [7-SEEA-p.18]

While contributing to science and national country are presented as a social value, the characteristics of a scientist are also mentioned below. In addition, the emphasis on TÜBİTAK scholarship encourages students to think that there is a need money to do a scientific study and that money can be found from some institutions that support scientific studies. In addition, students are taught to win Nobel Prize as a result of scientific work as one of the professional activities. Although it may cause some misunderstanding for M and SK categories, science, engineering and entrepreneurship applications (SEEA) section is very well prepared, and students are directed to this page in some activities throughout the textbook. Every emphasis on NOS can be made in more detail throughout the textbook instead of just highlighting in this section.

4.1.2.3.13. Summary of the Results of the 7th-Grade Science Textbook. To sum up the results of the 7th-grade science textbook it can be said that NOS emphasis has been attempted in the 7th-grade science textbook. However, under each category there are incomplete or misrepresented emphasizes. Looking at the code numbers and code names, it is seen that SP is well represented in the activity sections of the 7th-grade science textbook rather than other categories of science. However, the fact that all the representations are in activity and assessment shows that there is a need in the content parts to make a connection between scientists and students. The representation of AV is very inadequate. SK is represented well with the examples from history of science but still there is a need to integrate forms of SK and their connections. Besides, textbook has some references to M but there is a need to integrate more content and activities to explain and teach different methods to students.

When comparing epistemic, cognitive categories and social categories, it can be said that social categories have less emphasis in the 7th-grade science textbook than epistemic and cognitive aspects of science. However, although SOI and PA are social categories, they are well represented in the activity and content sections of the textbook. SE, SV, FS and PPS are the other social categories which are not represented adequately.

4.1.2.4. The Representation of NOS in the 8th-Grade Science Textbook. There are 11 subsections including results of representation of NOS in the 8th-grade science textbook based on AV, SP, M, SK, SCD, PA, SE, SV, SOI, FS, and PPS categories of science. Also, there are 2 subsections including SEEA and summary of the results of the 8th-grade science textbook.

4.1.2.4.1. The Representation of Aims and Values of Science in the 8th-Grade Science Textbook. While the “aims and values (AV)” of science are mostly included in the 2nd unit (f = 8), only one emphasis was made in the 4th, 5th and 7th units. The codes for AV are generally revolving around the ‘*serving to humanity*’ (f = 15) and ‘*empirical adequacy*’ (f = 5). Also, there are some other codes that are only mentioned once such as ‘*critical examination*’, ‘*generalizability*’, ‘*novelty and accuracy*’. ‘*Ease of life*’ and ‘*medical treatment*’ are the subcodes of the ‘*serving to humanity*’. For example, serving to humanity code referring treatment of illnesses, making easy of life was highlighted explicitly in the content part of the textbook as following.

The transfer of therapeutic genes to patients to inactivate and treat harmful genes is called gene therapy. With this treatment method, some diseases such as cancer and the negative effects of hereditary diseases can be eliminated. [8-2-CONT, p.65]

This quotation shows that the gene therapy which is one of the scientific works serves people by eliminating the negative effects of some diseases. In addition to this, the following excerpt which mentions serving to humanity explicitly indicates the people benefit from physics in their daily lives.

We benefit from gas pressure or Pascal's Principle in many areas, with or without awareness. For example, the hydraulic brake system in hundreds of vehicles we encounter in traffic every day is based on Pascal's Principle. [8-3-CONT, p. 87]

This quotation explains how people benefit from physics principles and shows that this principle makes easy the people live in a traffic. In addition to this code, empirical adequacy as an aims and values of science was mentioned with following.

As a results of his experiments with mercury-filled tubes using pressure, he determined the pressure falling to 1 cm² at sea level as 1033 gr / m². [8-3-CONT, p. 85]

The quotation implicitly mentions that the scientist conducts many experiments and reach a result based on sufficient, relevant and plausible data.

In brief, although the 8th-grade science textbook emphasizes the aims and values of science in general, it is noteworthy that the distribution is not very equal when viewed in terms of units. Emphasis on the aims and values of science is also seen to be combined in the code of serving to humanity generally, which is a social aim and value of science. Apart from this, it was concluded that there is just one reference to critical examination, novelty and accuracy codes whereas most of the aims and values of science such as objectivity, addressing anomalies and counter instances, challenges taking seriously, honesty and equality of intellectual authority were not mentioned in the textbook. Although there are some highlights it can be concluded that the 8th-grade science textbook is lacking in the aims and values of science.

4.1.2.4.2. The Representation of Scientific Practices in the 8th-Grade Science Textbook.

Representation of “scientific practices (SP)” were generally revolving around ‘*scientific explanation*’, ‘*observation*’, ‘*data*’, ‘*experimentation*’, and ‘*real world*’ with the frequency of 50, 30, 30, 19, and 20 respectively. Those codes generally gathered from the activity parts of the textbook that direct students to observe something or conduct experiment to collect data and explain their findings. Besides, there are some other codes such as ‘*discussion*’ (f = 17), ‘*model*’ (f = 13), ‘*representation*’ (f = 12), ‘*research*’ (f = 10), ‘*classification*’ (f = 8), ‘*inference*’ (f = 7), ‘*prediction*’ (f = 6), ‘*interpretation*’ (f = 6), ‘*analysis*’ (f = 2), ‘*social certification*’ (f = 1). For example, following excerpt including many codes such as experimentation, observation, data, scientific explanation, scientific reasoning and real world shows the connection between the scientific practices of science.

Record the distance the water travels from the hole on the ground by removing the bottom insulating tape. Observe the distance taken by the water coming out of the holes by removing all the insulating tapes, you have affixed. From which hole did the water travel the longest distance in your experiment with water? Explain. Has there been difference in the distances taken by the water and olive

oil coming out of the same hole? If so, what could be the reason? Explain. [8-3-ACT, p.82]

This statement indicates that textbook includes some scientific practices explicitly for students to perform them to reach scientific knowledge. The following excerpts from the 8th grade science textbook shows how activity encourages students to create a model and offer scientific explanation based on the created model.

Let's build a DNA model... ...What did you pay attention to while completing the opposite chain? Explain. Which molecule is the number of sugar molecules in your DNA model equal to? Explain. How many thymine bases did you use in your DNA model? Explain why. [8-2-ACT, p.41]

Also, there is an implicit reference to models as following.

Explain how the water cycle occurs by drawing in the section below. [8-6-ACT, p.214]

In this statement textbook aims students to create water cycle model, but textbook does not refer to create model. Even though textbook does not mention the “model” students draw the water cycle model, so it shows the existence of model code implicitly.

To sum up, scientific explanation, observation, real world, experimentation and data are the most highlighted codes in the entire textbook and in the units. The representation of SP which are the most highlighted category than other categories is adequate in the activity sections of the 8th-grade science textbook. Hence, there may be needed to mention the definitions and connections among the practices in content parts to introduce these practices.

4.1.2.4.3. The Representation of Methods and Methodological Rules in the 8th-Grade Science Textbook. There are no references that highlights the importance of domain general and domain specificity features of science. The experiments and observations only include step by step directions rather than allowing for working independently. Also, there are no statements referring non-hypothesis testing and non-manipulative testing methods in the 8th-grade science textbook. However, there is an explicit reference saying that scientists use ‘*scientific methods*’ as following

The systematic information that tries to find the events in a cause-effect relationship, analyzes the events based on scientific methods and reaches generalizations based on research and findings is called science. [8-1-CONT, p. 29]

However, this statement is not enough to teach which types of scientific methods that can be used by scientists, whether those methods differ in terms of different branch of science. '*Manipulative-testing*' (f = 18), '*hypothesis construction*' (f = 8), and '*hypothesis testing*' (f = 9) are most repeated codes both explicitly and implicitly in the activity parts of the textbook as following

...Repeat the same process as in Visual 2 by changing the places of the weights with the dynamometer. [8-5-ACT, p. 170]

Identical G loads are in equilibrium with F1, F2 and F3 forces in devices such that friction is ignored. According to this; if someone wants to prove that the gain in force depends on the length of the inclined plane, which two setups should one choose? Explain why. [8-5-ACT, p. 173]

Both examples from the textbook aims to teach manipulative testing by changing some variables. In addition to this, the second example includes hypothesis testing, but the textbook does not refer that there is a hypothesis, and someone try to test this hypothesis. Hence, this code was taken as an implicit reference to methods of science. Lastly, the 8th-grade science textbook includes some statements about the '*different branch of science*' (f = 5) but the differences and similarities among those branches were not mentioned adequately. *Different branch of science* was created as a code based on the explanations of the different principles related to science in the textbook as following

Ecology is the science that studies the relationships of living things with each other and their environment. [8-6-CONT, p. 211]

The branch of science that examines the spread of climates and their effects on humans and the environment in a cause-effect relationship is called climatology. [8-1-CONT, p. 24]

Those excerpts show that the 8th-grade science textbook explains different branch of science by giving descriptions of them but the links between these disciplines were not given.

In general, the 8th-grade science textbook has poor representation of M. Although in some parts of the textbook there are statements referring different branch of science, they do not refer the domain general and specificity features of science and it does not give students an opportunity to conduct their own experiments by considering variety of methods and determining how to investigate claims. Also, non-manipulative testing and non-hypothesis testing were not highlighted in the textbook. Besides, there are no explicit activity or content parts that encourage students to construct hypothesis and testing their hypothesis. The found codes are not enough to represent methods and methodological rules of science in an efficient way.

4.1.2.4.4. The Representation of Scientific Knowledge in the 8th-Grade Science Textbook.

The references of “scientific knowledge (SK)” were generally found in the 1st and 4th unit. The most repeated code is ‘*development of SK*’ (f = 11) in most of the units. In addition to this code ‘*tentativeness*’ (f = 4) Also, the frequency of the ‘*model*’ code is 3 and ‘*scientific knowledge*’ code is 2. The development nature of SK and tentativeness nature of SK and model were highlighted with the following statements in the content part of the textbook.

Although it was known that the hereditary characteristics of living things were passed on to their offspring for centuries, it was not explained for a long time how this transmission took place. Important studies on how to transfer hereditary traits to offspring were carried out by Gregor Mendel (Giregor Mendel) in 1860. Mendel revealed how hereditary traits are transferred to the offspring as a result of his studies with the pea plant. Mendel completed his studies in about 6 years. He published the results of the experiment in 1866. However, these studies were not understood until they were rediscovered in the early 1900s. [8-2-CONT, p. 45]

As a result of Henry Moseley's work, the periodic system was rearranged. Glenn Seaborg (Gilen Siborg) arranged the elements in two rows under the periodic system and finalized the periodic system we use today. [8-4-CONT, p. 101]

Even though the textbook does not say that the scientific knowledge develops the process of forming SK was mentioned with excerpts above. The excerpts also indicate that the references of scientific knowledge were found in generally content parts including history of science. Besides, the second excerpt explains periodical table as a model which one of the types of the scientific knowledge implicitly. Although there are many Sun, Earth and Moon models in the textbook, it does not mention that they are models. In addition to

these codes, ‘*systematic knowledge*’, ‘*theoretical knowledge*’ and ‘*law*’ are the codes which are repeated only one in the entire textbook. While textbook offers content that explains the development of scientific knowledge and its tentativeness nature it does not mention the connections between the theory, model and law which are the types of scientific knowledge.

Briefly, the 8th-grade science textbook includes some references to development of SK, but the textbook does not explicitly refer the model, theory and law as a form of scientific knowledge. Also, there is no statement saying that they work together and activities encouraging students to argument forms of scientific knowledge.

4.1.2.4.5. The Representation of Social Certification and Dissemination in the 8th-Grade Science Textbook. The 8th-grade science textbook includes ‘*dissemination*’ code including exhibition, presentation and sharing is most common code for each unit by a frequency of 21 out of 38. The following statements indicate that some activities encourage students to share their findings with their peers by exhibit or preparing posters. The following statement indicates that those activities might be prepared to teach dissemination ways.

Prepare a model for the conversion of electrical energy into heat, light or motion energy. Display the model you have prepared in your year-end exhibition and classroom board. [8-7-ACT, p. 245]

This statement shows that textbook include activity that direct students to prepare model and share them with their peers to inform them about presented model. Besides, ‘*publication*’, ‘*working with collaboration*’ and ‘*certification*’ are other codes which are represented more than other codes with the frequency of 7, 6, and 4 respectively. The statement about publication is below.

In 1644 he published a book on geometry and mechanics. In this book, which filled an important gap in the field of mathematics, Galilei's first work on mechanics was also concluded with the principle that the common gravity centers of interconnected bodies move downward while they can move suddenly. [8-3-CONT, p. 85]

This statement facilitates students to understand that scientists can publish a book related to their works to share their findings with others. The example from working with

collaboration and certification code that encourages students to work with their peers to reach scientific knowledge was given below.

What can you say about the pressures that the liquid in the container below exerts on points A, B and C on the bottom of the container? Discuss with your friends. Write down the decisions you made as a result of the discussion in the dotted areas below. [8-6-ACT, p. 91]

This statement indicates that students need to discuss their ideas with their peers and work in a group to provide agreement among them. Briefly, the 8th-grade science textbook includes many activities that promote students to share their findings or projects with their peers but in the content parts of the textbook there could be more emphasis on the certification process that scientists use.

4.1.2.4.6. The Representation of Professional Activities in the 8th-Grade Science Textbook.

The codes of “professional activities (PA)” category were generally revolving around ‘dissemination’ and ‘discussion of ideas’ codes (f = 17; f = 6). In addition to these codes, the textbook includes additional codes which are ‘peer review’ (f = 2), ‘publication’ (f = 1), and ‘preparing projects and reports’ (f = 3). The following example shows how the activity in the 8th-grade science textbook encourages students to prepare a project by searching and present it to their classmates.

Do a research on the efficient use of resources. Prepare a project with the information you obtained from the research. Present your project to your classmates. [8-6-ACT, p. 215]

The 8th-grade science textbook highlights discussion of ideas with following statement

...Discuss with your friends in the classroom what changes have been made to these tools and equipment to increase or decrease the pressure. [8-3-ACT, p. 80]

This statement might indicate that 8th-grade science textbook triggers students to discuss their ideas with others in the classroom as a professional activity. Briefly, the 8th-grade science textbook includes many activities that promote students to have different professional activities such as publication, dissemination, discussion and peer review.

However, there are no statements in the content part of the textbook highlighting the professional activities that scientists do such as attending conferences and writing articles etc.

4.1.2.4.7. The Representation of Scientific Ethos in the 8th-Grade Science Textbook. The 8th-grade science textbook does not represent “scientific ethos (SE)” category in a deep way. ‘*Intellectual honesty*’ is only one code which represents the SE with following statement.

Create discussion groups in the classroom about the positive and negative aspects of power plants and what could be potential risks. Note original ideas and display them on the class board. [8-7-ACT, p. 247]

The aim of this activity might be encouraging students to respect other ideas by creating something original and unique. This is the only highlight that has been clearly articulated on this category. But throughout the textbook scientific ethos are not represented well to teach it to students.

4.1.2.4.8. The Representation of Social Values in the 8th-Grade Science Textbook. ‘*Social utility*’ (f = 9) and ‘*doing no harm*’ (f = 7) are the most repeated codes which represent the “social values (SV)” of science as following.

Transferring therapeutic genes to patients in order to inactivate and treat harmful genes is called gene therapy. With this treatment method, some diseases such as cancer and the negative effects of hereditary diseases can be eliminated. [8-2-CONT, p. 65]

According to many scientists, acid rain is one of the biggest disasters. The way out of this disaster is to use renewable energy sources such as wind and solar energy that do not pollute the environment. [8-4-CONT, p. 124]

These excerpts indicate that the 8th-grade science textbook might explain the importance of social values of science by referring the social utility of scientific works like gene therapy and doing no harms while selecting the way to avoid acid rains. Besides, there are laboratory safety symbols section before the units. In that section, it is emphasized which rules should be followed in the laboratory. In this way, students can learn that there are some rules they should follow in the labs while conducting a scientific study.

Briefly, although the 8th-grade science textbook emphasizes that the studies should be based on social utility and that scientific studies should not harm anyone, it was concluded that these emphases were insufficient. The textbook, which does not emphasize the necessity of an environment of cultural freedom to encourage scientific research, also needs more emphasis on the fact that no harm to the animal or the environment while conducting a scientific study.

4.1.2.4.9. The Representation of Social Organizations and Interactions in the 8th-Grade Science Textbook. There are some codes such as *laboratory* (f = 5), *university* (f = 2), *factory* (f = 1), *nongovernmental organizations* (f = 2) and *institutions* (f = 1) for “social organizations and interaction (SOI)” in the 8th-grade science textbook. The following excerpts from the different units of the textbook show how the textbook represents the laboratory as a social organization.

It is understood that these studies carried out in the laboratory environment can push the boundaries of chemical structures and allow the formation of new chemical compounds. [8-4-CONT, p. 105]

The classical IVF method is the process of transferring the embryos obtained by combining the eggs collected from the ovary with the sperm taken from the male in a laboratory environment to the mother's womb. [8-2-CONT, p. 65]

Although there is not enough emphasis on this category in many units in the 8th-grade textbook, as can be seen from the above two examples, the textbook explains laboratories as places where scientific studies are conducted. Briefly, the 8th-grade science textbook has poor representation of social organization and interaction category of science because most of the units are lacking in reference to this category. While laboratory was the most repeated code in 2 units it is not enough to draw a general framework showing the interactions between the organizations.

4.1.2.4.10. The Representation of Financial Systems in the 8th-Grade Science Textbook. While emphasizing the ‘*commercial purpose of a product*’ obtained as a result of scientific studies was mentioned in only 2nd unit, there is a highlight on the ‘*contribution to the economy*’ in just 7th unit of the 8th-grade science textbook for “financial systems (FS)”. In

addition to these codes, 4th unit includes both ‘*investment*’ and ‘*incentive*’ codes to represent the need of money to conduct scientific works as following.

Since there is not enough information in the chemical sector and the private sector is an unknown field, there was no direct investment in this field other than a few simple workshops in our country in the 1950s. [8-4-CONT, p. 148]

These institutions and organizations contribute to the development goals of our country in this field with various incentives as well as the books and magazines they publish. [8-4-CONT, p. 148]

Those excerpts indicate that while the rest of the textbook does not have an emphasis on the financial systems, one unit also aims to teach students the need for investment and incentives for scientific studies.

4.1.2.4.11. The Representation of Political Power Structures in the 8th-Grade Science Textbook. The 8th-grade science textbook includes poor representation of “political power structures (PPS)” as a one of the categories of science. Only one of the units talks about the ‘*international initiative*’ and ‘*international treaty*’ whereas there is a more emphasis on the ‘*international cooperation*’ (f = 3) and ‘*government support*’ (f = 4) in some of the units. The statements from the different units which highlight the international cooperation are presented below.

Governments need to cooperate internationally in order to take the necessary measures against global climate change. [8-1-CONT, p. 27]

The only solution to fight this issue is for the countries of the world to cooperate more effectively against this problem. [8-6-CONT, p. 209]

These examples from the textbook may indicate that international cooperation has an effect on the scientific works and so it might be said that political powers have an effect on the scientific works. By looking at the codes and their frequencies it can be said that the 8th-grade science textbook is not well-qualified to represent the political power structures because the references is limited to emphasize the effects of the ideological power such as politics, race, religion or gender.

4.1.2.4.12. Science, Engineering and Entrepreneurship Applications. Science and engineering and entrepreneurship applications (SEEA) are not included in the introduction of the 8th-grade science textbook. At the end of each unit, a text that students can read is provided. These are usually examples from the history of science. Here, the studies of scientists and the development of scientific knowledge are emphasized. The codes of these stories were examined in terms of categories and added to the frequency values in previous sections. Apart from these stories, design cycle steps are given at the end of each unit and students are aimed to design a model to solve a problem and present it. The design cycle step and content are the same as presented in the 5th-grade textbook. Students are assigned to design a model to solve one of the human problems by discussing, searching, being original and using low-cost products. These can be considered as an emphasis on the SV, SE and FS categories. Lastly, students are encouraged to present their models with others via internet, exhibition and science fests. These statements also include some references to SCD and PA categories.

4.1.2.4.13. Summary of the Results of the 8th-Grade Science Textbook. To sum up, the 8th-grade includes at least one code for each of the categories of science, but their representations are not enough to teach NOS in science classrooms. Although there are some highlights for AV, the 8th-grade science textbook is lacking in most of the aims and values of science. SP, SCD and PA are the categories were represented well in the activity sections of the 8th-grade science textbook. Hence, there is a need to integrate knowledge about these categories in content part of the textbook to show the connections among the scientific practices, social certification and dissemination process and what activities scientists participate in.

Besides, there are very poor representation of AV, SK, SE, SV, FS and PPS categories even though some of the codes were found in some of the units both explicitly and implicitly. Besides, the stories from the history of science given in the Science, Engineering and Entrepreneurship Application section are useful for students to understand the development of scientific knowledge, the fulfillment of human needs as an aim of science, and what kind of studies scientists do. However, there is only an emphasis on engineering, not on scientists in the design cycle step.

4.1.2.5. Summary of the Representation of NOS in Each Science Textbook. As a result, it was found that the epistemic and cognitive aspects of science were emphasized more than the social-institutional aspects of science in the 5th, 6th, 7th, and 8th- grade science textbooks. While there are more various references on SP in all the textbooks examined, it has been found that the vast majority of these references are in the activity sections. Although there is emphasis on the AV, no textbook has enough references to explicitly teach this category. Although similar emphasis is found in every textbook on scientific methods, there is not well and adequate emphasis on the diversity, domain general and domain specific features of scientific methods. There is a misconception in all the textbooks examined that activities are given as steps to be followed. Although all textbooks do not explicitly emphasize hypothesis construction within the units, they implicitly encourage students to formulate hypotheses. In general, the development of scientific knowledge is explained with historical examples in each textbook. However, no textbook emphasizes that theory, model and law are a type of scientific knowledge, how they develop and their relationship with each other.

Within the social categories, most emphasis was found on the SCD and PA categories in each textbook. However, these categories are emphasized more in the activity sections. The most obvious emphasis on these categories is in the SEEA section of the 6th-grade textbook. SE and SV categories are not sufficiently emphasized in any textbook, but the only explicit emphasis on SV is in the laboratory safety section of the 6th- grade science textbook. Although social institutions are presented with many different examples, especially in the 7th- grade textbook, examples are also found in other textbooks. Although there are some references, each textbook failed to reveal the interaction between institutions clearly. Finally, FS and PPS are not sufficiently represented in any of the textbooks.

4.2. Results of the Science Teachers' Perceptions on NOS and Science Textbooks

The 2nd, 3rd and 4th research questions of this study are about the teachers' perceptions and understanding towards NOS, using of science textbooks to teach NOS, and teachers' perceptions and suggestions about inclusion of NOS in science textbooks. In order to answer second question, first part of the teacher interview protocol was administered to participants and then "NOS Questionnaire" was applied. For the 2nd research question, second part of the

teacher interview was completed and science teachers' perceptions towards using science textbooks were explained under some subsections such as using science textbooks in science lessons, using alternative science textbooks in science lessons, the importance of teaching NOS and using science textbooks to teach NOS. In the 3rd part of the teacher interviews science teachers' perceptions and suggestions on representation of NOS in science textbooks were answered and the results are presented in terms of epistemic and cognitive aspects of science and social-, institutional aspects of science.

4.2.1. NOS Understanding and Perceptions of the Science Teachers

The 2nd research question of this study is that “How do science teachers understand and perceive Nature of Science (NOS) in terms of aims and values, scientific practices, methods, scientific knowledge and social-institutional systems of science?”. In order to answer this question semi-structured interviews were held, and questions related to RFN categories were administered to participants. One week after the interviews, the teachers answered the questions in the “NOS Questionnaire”. Quantitative results from the “NOS Questionnaire” and qualitative results from interviews are explained in the following subsections.

4.2.1.1. Quantitative Results. Descriptive statistics results show that the total “NOS Questionnaire” scores of teachers are ranged from 273 to 298 out of 350 with the mean value of 287,8. Akgun and Kaya (2020) identified the participants' level of NOS understanding by specifying score intervals based on the minimum and maximum scores of the “NOS Questionnaire”. The participants having the total scores of the “NOS Questionnaire” between 200 and 235 have a low-level NOS understanding, those between 236 and 270 have a moderate level NOS understanding, and those between 271 and 305 have a high-level NOS understanding (Akgun & Kaya, 2020). According to Akgun and Kaya's (2020) grouping, all of the teachers participating in this study have a high-level NOS understanding.

The possible maximum scores based on the categories of “NOS Questionnaire” which are “aims and values (AV)”, “scientific practices (SP)”, “methods and methodological rules (M)”, “scientific knowledge (SK)”, “social-institutional systems (SIS)” and “educational applications (EA)” are 35, 65, 45, 45, 90 and 90 respectively. In this study, the

scores for the AV are ranged from 21 to 29 with the mean value of 26,37. The scores for the SP are ranged from 48 to 63 with the mean values of 54,75. The scores for the M are ranged from 23 to 36 with the mean values of 28,75. The scores for the SK are ranged from 32 to 38 with the mean values of 35. The scores for the SIA are ranged from 63 to 76 with the mean values of 71. Lastly, the scores for the EA are ranged from 66 to 75 with the mean values of 72. Even though participants have a high level of NOS understanding, it is seen that the participants' understanding of the M, SIA and EA categories is lower than the other categories.

4.2.1.2. Qualitative Results. In this section, qualitative results gathered from the interviews were explained under each category of Reconceptualized Family Resemblance Approach to Nature of Science (RFN).

4.2.1.2.1. Aims and Values of Science. Science teachers were asked what the “aims and values (AV)” of science are. They explained that ‘*ease of life*’, ‘*understanding of universe*’, ‘*explanation of universe*’, ‘*development of technology*’, ‘*discovery*’, ‘*building cause-effect relationship*’, and ‘*empirical adequacy*’ are the aims of science. Apart from these, some participants emphasized that science has an ‘*monetary aims*’ while others said that it has ‘*spiritual aims*’. Almost all participants stated that satisfying human’s ‘*curiosity*’ is one of the most important aims of science. While participants explain the epistemic, cognitive and social values of science they generally mentioned that ‘*social utility*’, ‘*animal care*’, ‘*respect for environment*’, ‘*intellectual honesty*’, ‘*decentralizing power*’ and ‘*doing no harm*’ are the values of science.

4.2.1.2.2. Methods and Methodological Rules. When “methods and methodological rules (M)” were asked to participants, they gave similar codes such as ‘*experimentation*’, ‘*observation*’, ‘*research*’, ‘*interpretation*’, ‘*data collection*’. All participants stated that scientist can use ‘*different methods*’ to reach scientific knowledge. Also, most of them talked about the ‘*different branch of science*’ and emphasized ‘*domain specific features*’ of science by giving examples from other branches. In addition to these codes, some of the teachers mentioned ‘*domain general*’ features of science by highlighting some methods which are proceed step by step such as ‘*asking questions*’, ‘*construction of hypothesis*’, ‘*experimentation*’, ‘*hypothesis testing*’, ‘*supporting claims*’, ‘*manipulative testing*’ and

'verification by trying'. One of the participants who think that there are many methods in science he explained them as cookbook as following.

Because first of all, you need to define a problem first to do research or have an idea about a topic. Of course, you collect information about this and, in the light of this information, you make a statement about the current problem, which was called a hypothesis, if I remember correctly. Then you confirm again whether the hypothesis is correct or not, and the process proceeds like this. [Participant-5]

The quotation indicates that the teacher has a naïve understanding of M. During the interviews with teachers, it was observed that teachers always mentioned hypotheses and manipulative testing as a method of science. Although they emphasize that different branches use different tools, the teachers never mentioned non-manipulative and non-hypothesis testing which are the methods of science.

4.2.1.2.3. Scientific Practices. When teachers were asked what comes to mind when “scientific practices (SP)” are said five science teachers stated that they had never heard this concept before. After the researcher asks the same question with different forms, it was observed that the teachers still had naive views about the practices. For example, one of the participants defined SP as

Things that science constantly does... ..things that science constantly tries, it can be trial and error. [Participant-6]

Also, some of the participants identified SP as *'easy method'*, *'doing practices'*, *'doing something frequently'*, and *'practical science'*. On the other hand, the remaining two participants mentioned *'observation'*, *'real world'*, *'data collection'*, *'evaluation of data'*, *'representation'*, *'experimentation'*, and *'using appropriate tools'* as scientific practices. Also, one of the participants emphasizing the relationship between the practices.

4.2.1.2.4. Scientific Knowledge. When teachers were asked to explain the “scientific knowledge (SK)”, they did not mention laws, theories and models as forms of the scientific knowledge but one of them define SK as *'explanation of phenomena'* While participants defined the SK, they generally emphasized the nature of SK. All the participants stated that scientific knowledge is proven and depended on scientific evidence. Also, some of the

participants emphasized the refutable nature of SK to test or observe that how SK can be false or true. In addition, almost all participants stated that the SK can change based on new evidence or new interpretation of existing evidence. In the light of these explanations, some codes presenting the nature of SK were generated. They are *'credible'*, *'falsifiable'*, *'tentative'*. Also, *'development of SK with technological advancements'* code was gathered from almost all participants while they were explaining how SK can change.

4.2.1.2.5. Social Certification and Dissemination. The participants highlighted that scientific knowledge can be disseminated via some channels such as *'publication'* (article, journal, book etc.), *'broadcasting'* (television, radio, internet, social media etc.), *'conferences'*, *'symposiums'* and *'international congress'*. Some codes which are *'sharing with other scientists'*, *'informing society'*, *'international collaboration'* and *'sharing publicly understandable knowledge'* were generated from the participants' explanations about the aim of the dissemination. Moreover, the participants explained the certification criteria. They are *'empirical adequacy'*, *'peer review'*, *'using reliable resources'*, *'being familiar by others'*, and *'verification by trying'*.

4.2.1.2.6. Scientific Ethos. The participants generally answered the questions related to "scientific ethos (SE)" and "Social Values (SV)" in a similar way. After the participants were asked to think about the scientific ethos that scientists pay regard while conducting scientific investigations, they listed some ethos. Some codes generated under SE category are *'intellectual property'*, *'sharing knowledge'*, *'social utility'*, *'collaboration'*, *'respect for environment'*, *'respect'*, *'equality of intellectual authority'*, *'objectivity'*, *'empirical adequacy'*, *'openness'*, *'protecting human subject'*, *'social utility'*, *'transparency'*, *'intellectual honesty'*, *'moral values'*, and *'animal care'*.

4.2.1.2.7. Social Values. The participants gave some similar codes to SE for in this category. They are *'social utility'*, *'transparency'*, *'intellectual honesty'*, *'moral values'*, and *'animal care'*. One of the participants explained transparency and animal care with following statements.

So, I think they should present the information without distorting it...
... That is, they should not manipulate the situation just because it is what they are aiming for, or, for example, animal experiments, that is, things are tried on

animals. It may be makeup materials, medications, shampoos, I do not find it right to test them on animals. [Participant-3]

On the other hand, one of the science teachers explained social values of science as *'religious values'*. Also, one of them thought that *'favoring interest of government'*, and *'community development'* are the social values of science that scientists should pay regard while conducting scientific investigations.

4.2.1.2.8. Professional Activities. When the participants were asked what “professional activities (PA)” scientists can engage in, the participants listed many types of professional activities for scientists. They are *'participating in conference'*, *'sharing SK with society'*, *'sharing SK with other scientists'*, *'publication'*, *'organizing workshops'*, *'dissemination'*, *'doing research'*, *'making discovery'*, and *'making observation'*. In addition to these codes, one of the participants defined professional activities as *'motivational activities'* such as *'having a pet'*, and *'travelling'* by emphasizing that scientists are like any human beings as following.

Scientist motivation is very high. Every scientist has their own professional thing that increases their motivation, it can be feeding a dog, going out at midnight or making their bed There is definitely what motivates themselves. [Participant-4]

Also, one of the participants listed some of the characteristics of scientists under this category such as *'being skeptical'*, *'being patient'*, *'perseverance'*, and *'being objective'*.

4.2.1.2.9. Social Organizations and Interactions. The participants gave many examples for social organizations that scientists do scientific works. They are *'laboratories'*, *'universities'*, *'schools'*, *'hospitals'*, *'government institutions (TÜBİTAK, Teknopark, BİLSEM)'*, *'science centers'*, *'independent research centers'*, *'campaigns'*, *'foundations'*, and *'museums'*. Also, some of the participants stated that there is no need for any social organizations because scientific studies can also be done in the *'self-workplace of scientists'* and *'free from any place'*. Lastly, two participants emphasized the importance of *'collaboration among stakeholders and organizations'* while conducting scientific explanations.

4.2.1.2.10. Financial Systems. All participants stated that there is a '*need for money*' to conduct scientific studies and disseminate scientific knowledge. When asked where scientists can get the money for their studies, all participants said that government should provide financial support and budget for scientific investigations. Some of them gave examples for opportunities of '*governmental funding*' in Turkey such as TÜBİTAK and YLSY scholarships and state treasury. One of the participants stated her opinions about need for money and where scientist could get money as following.

Of course, they need a money... For example, this is of course a material thing, they were using very advanced technologies, most likely, therefore, you should have a financial need.

... They can find from the treasures of countries, I guess there is a budget allocated for this. [Participant-2]

Besides, some other codes such as '*private sector funding, self-funding, and marketing of scientific products*' were generated from some of the science teachers' answers. Also, one of the participants explained that financial systems affect science because lack of funding can cause '*interruption of scientific works*'.

4.2.1.2.11. Political Power Structures. All participants thought that "political power structures (PPS)" can affect science in different ways. They emphasized that '*ideological constraints*', '*government constraints*', '*social construction of gender*' and '*governmental funding*' may affect science negatively. Also, governments can permit to conduct scientific studies that are in line with the '*interest of the governments*'. Hence, conflict of interests and benefits have an effect on shaping science. Also, one of the participants said that scientific investigation can affect politics reversely.

4.2.2. Science Teachers' Perceptions of Using Science Textbooks

Some preliminary questions were asked to participants in order to answer the 3rd research question of the study related to teachers' perceptions towards using science textbooks in addressing NOS. It was asked whether teachers use science textbooks in their lessons, the reasons for these, whether it was important to teach the nature of science to students, and whether they use alternative textbooks. In the light of the answers to these questions, some other questions were asked to find out whether the teachers use science

textbooks to teach NOS and which grade level they think the science textbook emphasizes more on NOS.

4.2.2.1. Using Science Textbooks in Science Lessons. All but one of the science teachers said that they used science textbooks in their lessons. In line with the answers of the teachers, they were asked why they do not use science textbooks or for what purpose they use them. The teachers generally stated that textbooks are '*primary lesson materials*', and they offer '*free access*' to all students. Also, almost all teachers said that they use science textbooks for '*preliminary preparation*', and they are just benefitting from science textbook before the lessons for '*preparing lesson plans*' and '*checking objectives or contents*'. One of the participants explained for what purpose she uses science textbook as following.

Yes, first I look at the textbooks, frankly. I examine the achievements and what we need to give, but after reviewing the textbook, I do not hold to the textbook, so I look at the book, of course, but I look at other sources. In other words, I want to see the information and content that the national education really wants to give. [Participant-3]

As can be seen from the excerpt, the participant usually uses the textbooks to control what subjects she should include and what information she should give students before the lesson. Later, she mentions that she is planning her lesson without depending on the textbook.

On the other hand, some of the participants stated that they do not use science textbook because of some reasons. Those reasons are that science textbooks include '*misinformation and misconceptions*', also they do not encourage students to learn, and they are '*lack of NOS emphasis*'. One of the participants from private school stated that they are not use science textbooks actively in science lessons because their language of instruction is English. They just look at the objectives and contents to include their online or video-typed lessons. One of the participants stated that he does not prefer to use science textbooks in his lessons because of some reasons given at below.

To be honest, I have not looked at the textbooks given by the Ministry of National Education for five years. The reason is that the source I used should not include any scientific mistakes. However, there is a constant misinformation and misconceptions in MoNE resources. I am teaching at 8th grade this year. Every

year, every year there is a scientific misinformation in the textbooks.
[Participant-2]

As a result of the interviews, it can be said that some of the teachers do not benefit from science textbooks at all, while others used it only in the planning phase. In this case, it might be interpreted that none of the interviewed teachers used science textbooks during the science lessons.

4.2.2.2. Using Alternative Science Textbooks in Science Lessons. When the participants were asked whether they use alternative science textbooks in their lessons, they all stated that they use an additional source. While 3 of the participants stated that they use an additional question bank instead of the textbook, 5 of them said that they use the alternative science textbooks.

Some of the participants stated that they use many alternative textbooks based on their '*students' cognitive levels*'. They also prefer to use alternative textbooks because they have '*richer content*', they include '*diversity of real-world examples*' and '*diversity of ability-based questions*'. Also, teachers use alternative science textbook for '*preparing lessons*' in terms of the objectives, '*giving homework*', '*using in problem sessions*' and '*preparing students for high school entrance exam*'.

The excerpt of a participant who explained why he need to use an alternative source by revealing some of the shortcomings of science textbook given by MoNE, is below.

The system pushes me to use additional books. Because it will be a very serious criticism, but while you are preparing the content of your textbook, if your preparing approach and your approach to evaluate the process are 180 degrees opposite from each other, you are condemning the students to use the additional books. This is an obvious fact. What do we expect from the student? We expect the information to be readily learned, structured, and solved, we expect students to transfer the assimilated information to new problem situations, create products and make them subjective. But if the system administrates a multiple-choice exam for high school entrance unfortunately, you have to use alternative books.
[Participant-6]

The teacher thinks that the textbooks do not prepare students for the high school entrance exam they will take at the end of the 8th-grade. In this case, he says, the students

need to use alternative question banks or textbooks. Another participant explaining why she used an alternative textbook is as follows.

I use alternative textbooks....

...actually I use it to ask different questions to students in order to increase the variety of examples, or if there are activities, I want to see them. Can we do more activities? I look at it according to the time. Accordingly, I use other books.

[Participant-3]

In general, the reasons for the participants to use alternative textbooks can be summarized as the textbooks given by the Ministry of National Education (MoNE) are inadequate in some issues or some teachers want to use additional content to the content of the textbooks given by MoNE.

4.2.2.3. Importance of Teaching NOS. Before asking whether participants use science textbooks while teaching NOS, they were asked whether it is important to teach NOS to students. All of the participants emphasized the importance of teaching NOS. Most of the teachers stated that teaching NOS is important to generate scientifically literate students. Some of the participants also mentioned that teaching NOS helps students to understand how science works and what scientific research process are. According to some of the participants, while teaching NOS, students learn how to reach SK, learn the development of SK with the light of the science history and Also, evaluate SK from different sources. Besides, one of the participants thought that teaching NOS increases students' imagination and curiosity, encourages them for self- research and observation as follow.

It is important to teach the nature of science. Because in the age we live in, we need to be more interested in science and technology, and the basis of these may be the nature of science. For example, we can broaden students' horizons by teaching methods and thinking techniques and how knowledge can change.

[Participant-3]

Also, one of the teachers said that teaching NOS expands students' horizon because they gain scientifically thinking skills. When teachers were asked what they are doing to teach NOS, almost all teachers said that they could not spare much time to teach the nature of science. However, they mentioned that there is an elective course named as application of science in schools. According to participants, the content of that course completely fits

the nature of science. However, the same teachers stated that they generally solve questions or repeat the science subjects in this lesson.

Teachers stated that they integrate scientific methods such as observation, experimentation, construction of hypothesis, manipulative and hypothesis testing to their lessons to teach NOS. Some of them said that they teach NOS by visiting online science centers and watching documentary to discuss about them. Besides, one of the teachers explained that she does many activities to teach NOS students. For example, students work in a group to research and see development of SK in her lessons.

Briefly, it can be said that all teachers are aware of importance of teaching NOS. Also, some of them doing some activities to teach epistemic and cognitive parts of the NOS but they did not emphasize any things related to social parts of the science. In addition to this one of them mentioned teaching financial systems and political power structures to students is not necessary.

4.2.2.4. Using Science Textbooks to Teach NOS. After learning about teachers' opinions about science textbooks and the nature of science, teachers were asked whether they use science textbooks to teach the nature of science. Although 2 teachers said that they use the science textbooks to teach the nature of science, they could not explain detailly how they use them. One of the teachers who used the textbooks said she uses the textbooks to brainstorm students and present real-life examples. The remaining 6 teachers stated that they do not use the textbooks in NOS teaching because of the insufficient emphasis on the nature of science in the books. In addition, a teacher said that the textbooks do not increase students' curiosity so he could not use the science textbooks to teach NOS.

When the teachers were asked in which grade level textbook there was more emphasis on the nature of science, 3 teachers said that the 5th-grade science textbook emphasizes NOS more. The reason is that 5th graders are the first grade of middle school, so they do not prepare for the high school entrance exam. Also, they said that there is more experimentation, observation, data collection and scientific explanation activities and more sections from the history of science and the lives of scientists in the 5th-grade science

textbook. Two teachers stated that the topics of the 6th-grade textbook are more suitable for NOS and there are more activities triggering curiosity so learn science.

Apart from this, one teacher thought that 7th and 8th-grade science textbooks include more physical subjects than others, so these textbooks have more emphasis on NOS. Besides, one teacher said that the 8th-grade textbook contains more manipulative testing activities than other grade textbooks, and therefore this book emphasizes more on the nature of science. Lastly, one teacher stated that he has no idea which level of the book emphasizes more NOS.

4.2.3. Science Teachers' Perceptions and Suggestions on Representation of NOS in Science Textbooks

The 4th research question of this study is that “What are the teachers’ perceptions on representation of NOS in science textbooks?”. In order to answer this research question, teachers were asked whether each RFN category could be found in the textbooks. Later, the participants made suggestions on how to include statements on RFN categories if they felt they were not sufficiently found. The participants’ perceptions and suggestions are presented in two subsections which are epistemic and cognitive aspects of science and social-institutional aspects of science.

4.2.3.1. Epistemic and Cognitive Aspects of Science. While 5 of the participants think that the emphasis on the “aims and values (AV)” of science is insufficient in the textbooks, two participants think that there is the sufficient existence of NOS in the textbooks and one of them stated that NOS emphasis in textbooks is completely absent. When asked how to include the aims and values of science in science textbooks, various suggestions came from the participants.

Science teachers generally suggest that activities such as observation, experimentation, reflection questions, reading passages, puzzle activities, images, stories, interesting information boxes can be included in the science textbooks to teach aims and values of science. Also, one of the participants emphasized on the technology integration such as QR codes or Augmented Reality (AR) in the textbooks for directing students to

different platforms. In addition to these suggestions one of the participants emphasized the importance of integrating the history of science in the science textbooks to teach aims and values of science as follow.

There may be a very short article about who Louis Pasteur is, what he did, what he discovered...

..In the textbooks there are questions to explain and teach the subjects. But let the children learn, for example, why Louis Pasteur discovered the Pasteur pipette. For example, we always use the Pasteur pipette, we go to the lab, we tell the children that this Pasteur pipette is very nice, but why do we use it? Why did this guy discover this and why he found it? Because he was working with microorganisms, he had to take tiny tiny samples. I think such things should be incorporate into those books a little bit. [Participant-5]

The teacher stated that there are stories from the history of science in the science textbooks, but student can learn aims and values of science if those stories explicitly include aims of discoveries. When the opinions of other teachers are listened to, it can be said that AV can be generally taught with different types of activities.

For the “methods and methodological rules (M)” category, the participants stated that there was the most emphasis on this category in the textbooks. However, they also stated that this emphasis was insufficient and should be improved. Many teachers said that different types of methods should be integrated into science textbooks. Some of the participants also suggested that the methods given in the textbooks are generally followed step by step, and instead, activities that increase students’ curiosity and can determine their own methods should be included. Some of the participants also emphasized that the science subjects in the textbooks should be simplified in order to make more emphasis on the methods.

Besides, one participant said that various methods used in science can be taught to students through animation and storytelling activities which are integrated into science textbooks. Apart from this, one of the teachers explained that it is important to teach other branches of science to students and that this should be included in the textbooks with the following example.

We have to give children the interdisciplinary interaction, in fact, as I said, we should teach that each method is a different way of working in each branch of science. If possible, it may be related to that subject, for example, we are working

on the formation of the seasons in the eighths, associating this issue with geography and how this subject is addressed to children in terms of geography can be included in the books. [Participant-7]

This quote indicates that it is possible to teach students the diverse disciplines and the variety of methods used there, and to include them in textbooks.

When asked whether there are expressions about “scientific practices (SP)” in the science textbooks, 3 teachers said that scientific practices were represented sufficiently in the textbook, while 5 teachers were of the opinion that the emphasis on scientific practice in the textbooks was insufficient. Most of the teachers think that the number of activities related to scientific practices should be increased. Apart from this, it is thought that scientific practices can be taught by including pictures, texts describing practices, questions that lead to research, and do you know these boxes.

In addition to these, a few teachers explained that there should be more real-life examples in the science textbooks. Also, one of them stated that the experiments which can be done at home by using simple materials should be included in the textbooks as below.

Not every country has a laboratory to give children the experience of experimenting. But very simple experiments can be set up and child can draw conclusions from it. For example, there is an acid-base experiments. Some of the vegetables at home, such as cabbage juice and lemon can be used to conduct an experiment. Why does that experiment not in the textbooks? We should include examples from real life experiments the child can do at home. Here is the name of these activities in kitchen science, science in the neighborhood, etc. [Participant-2]

As can be seen from the quotation of the teacher, although there are activities such as experimenting and observing in the science textbooks, it is emphasized that in these activities, real-life connections should be established and the experiments that students can do with materials which can be easily accessed in every environment should be included in the textbooks to teach SP.

When asked about how “scientific knowledge (SK)” is represented in the science textbooks, 3 of the teachers stated that statements about SK is exist in the science textbooks but 5 teachers said that the emphasis on SK is definitely insufficient in the science textbooks.

These teachers, who said that scientific knowledge is given to students only as absolute knowledge argued that SK can be taught in a better way with integration of current information, newspaper news, documentary links and pictures into science textbooks.

One of the teachers said that examples of female scientists from the history of science to teach development of scientific knowledge should be included in science textbook. In addition, one of the participants stated that students should access information not readily, but through research. The inclusion of this in the textbooks is explained below.

...the book should be a guide to the child, not providing information directly. That is, if there is all information in the textbook, the child does not research it anyway. The textbook should be directing, so it should say look, do these, save the results here, research them, use this website, search from other sites yourself, save them or do these activities, observe them, and then come to the lesson. Already later there will be learning. [Participant-2]

As can be seen, it is recommended to include activities that enable students to reach information in the science textbooks. Apart from this, one of the teachers stated that scientific knowledge can be constantly changed and developed. He stated that development of SK should be included in every subject in the textbooks. He said the following about this.

For example, you are talking about non-flowering plants. Textbook says that horsetail, liverwort or fern are non-flowering plants. But flowerless plants are not just made up these examples, because why research is still ongoing. When the textbook says that this is what has been found so far, but from now on non-flowering plants will definitely be detected, the students find something like fern while walking on a mountain and can say that they discover this because this is not in the textbook. Thus, s/he can feel himself/herself as a scientific person. Therefore, the textbooks should allow the student to think about development of SK in most of the subjects. [Participant-5]

According to the teacher's opinion, scientific knowledge can be taught not only in one subject but in many subjects. Thus, when students learn scientific information, they learn that it can actually change over time with new studies and continues to research in their own life.

4.2.3.2. Social- Institutional Aspects of Science. The science teachers were asked what they think about whether the expressions related to “social certification and dissemination

(SCD)” exist in the science textbooks. While 3 of the teachers stated that these expressions were not found in the textbooks, 5 of them stated that the emphasis on SCD was insufficient.

The teachers emphasized that SCD is an important concept and that it is important to include it in the science textbooks. One teacher said that current news such as vehicle sent to mars or presence of water on the moon can be included in the textbooks to be used in the next year, and it can be shown to students that scientific knowledge can also be spread through textbooks. During the interviews, the participants made several suggestions for the inclusion of the SCD in the textbooks. It was suggested to include games and discussions in the textbooks that would encourage students to share their knowledge. One teacher said activities that would allow students to work in groups while experimenting and compare their results with other groups should be included in the textbooks. One of the teachers explained that SCD should be reduced to the cognitive level of the students and supported by various activities as follows.

We do not say children to read some of the articles. SCD should be included in textbooks so that it should be reduced to their cognitive level. For example, there is one application. Children take on a role somehow and then they come up with a product. For example, such an activity can be added to the textbooks. These events can say this. ‘You are a scientist, now do these things like a scientist. Make an interview and prepare a public spot.’ These can be integrated in the textbooks. For example, I have never seen such a thing in the textbook.... ...Indeed, these kinds of activities are something that increases the questioning skills of children as well as their presentation skills. [Participant-4]

As can be seen from the excerpt, the teacher cares about having SCD activities in the science textbooks. At the same time, many teachers thought that the number of expressions such as exhibit, present, share in the textbook should be increased. Apart from this, a teacher stated that the textbooks should contain statements or links that direct students to the websites of institutions such as TÜBİTAK, where scientific knowledge is included.

Six of the science teachers interviewed mentioned that the emphasis of the “scientific ethos (SE)” category is absent in the science textbooks, while 2 of them said that even if SE is found in the textbooks, it is insufficient. Although one of the teachers said that the emphasis on SE was low in the textbooks, he stated that the inclusion of SE in the science textbooks is not necessary. He explained his thoughts as follows.

I do not believe that SE should be directly in the textbooks. Because for me you shouldn't expect everything from the textbook. But this is a process that the teacher should take into account and value in the teaching process. In other words, while you give your students the opportunity to present the results of their experiments by forming small groups if you see that your student overhears and shares the results of the experiment of other groups, not the results of his own experiment, you should intervene. [Participant-6]

As can be seen, this teacher does not need to explicitly include SE in the science textbooks. On the contrary, a teacher says that SE should be given explicitly without being absorbed into the topics in the science textbooks. Another teacher suggested that in order to teach SE to students, sections containing information and activities related to SE should be added to the starting pages of the science textbooks of each grade level. Participants stating that the number of activities should increase suggested that the reading text, newspaper news and stories from the history of science should be included in the science textbooks to teach SE. Finally, one of the participants argued that the intensity and content of the emphasis on SE should increase as the grade level increases.

Likewise, almost all of the teachers said that “social values (SV)” do not exist in the science textbooks. They suggested that stories from the history of science and discussion activities on social values can be included in the textbooks in order to teach SV to students. One teacher said that although theater or story writing activities could be added to the textbooks, this suggestion is not very realistic. Because she thought that increasing the emphasis on SE in the textbooks may delay the teaching of the subjects in the curriculum. Finally, there is also a teacher who thinks that SV emphasis should not be directly included in the textbooks, as in SE.

Participants who made suggestions for the inclusion of “professional activities (PA)” in the textbooks generally think that the textbooks are lacking in this category of science. It has been said that PA can be taught by including examples from the history of science, video links in the textbooks. In addition, one of the teachers suggested that the science textbooks should include activities for students to share and discuss the knowledge they obtained like a scientist with students from different schools. While one of the teachers suggested to include information and activities related to PA in the science textbooks, he also stated that he had very little knowledge on this subject and that he should learn.

Besides, there are 4 teachers who say that the statements of “social organizations and interaction” are not found in the science textbooks. Apart from this, one teacher stated that there is emphasis on SOI, while 3 teachers stated that the emphasis is not adequate in the textbooks. Considering the suggestions of the teachers, it is said that the teaching of this category may be possible by including the photographs of science centers, zoos and observatories in the textbooks, and by explaining the different institutions and their interactions with each other in the information corners.

Most of the participants stated that statements or activities about “financial systems (FS)” and “political power structures (PPS)” do not exist in the science textbooks. Several teachers said that the need for money is often expressed in extracurricular projects like TÜBİTAK. Some of the teachers said that the expressions of FS and PPS do not need to be in the middle school science textbooks. On the other hand, teachers who defended the view that the integration of FS and PPS in the textbooks is important to teach the nature of science, suggested that stories from the history of science, information about possible scholarship programs, intriguing questions, and research assignments should be included in the science textbooks. How these activities can be included in the science textbooks to teach PPS was stated by a teacher as followings.

While telling the history of science, how science is influenced by political thoughts can be taught to children. For example, the story about the decapitation of Galileo claiming that the earth revolves around the Sun can be included. At that time, religious beliefs tried to influence the science, but Galileo opposed it and paid the price with his life. [Participant-1]

...to look at science as pure science, that is, to focus only on the work that person does, regardless of which race, nationality, religious belief, these are not in the textbook, as I said, if the teacher gives this or the child is curious, they learn, so as I said, at the end of the unit, either the research task or the something like a booklet on the history of science can be printed and distributed to children like a storybook. [Participant-1]

Also, the same teacher who emphasize that science should not be influenced by religion, politics and race, offered some suggestions on where to include the PPS in the textbooks as above.

4.2.4. Summary of the Teacher Interview Results

During the interviews with teachers, many sub-questions were examined, and their opinions about science textbooks were revealed, whether they used the science textbook books to teach NOS, and the teachers' opinions about the representation of NOS in the textbooks were determined and their suggestions were listened. As a result of the interviews, teachers have high NOS understanding. On the basis of the RFN categories, it was determined that SP and M categories were explained less than other categories.

All teachers except one teacher use science textbooks in their lessons. However, the answers from the teachers showed that the textbooks are used only in the preliminary stage of lessons. The teachers said that they used alternative books in their science classes because textbooks have some deficiencies in many aspects. The participants stating that it is important to teach the nature of science to children, mentioned that that they do not use the textbooks to teach NOS because the textbooks are insufficient in this regard.

Almost all of the teachers stated that the science textbooks are lacking in terms of including NOS. The idea has arisen that the categories AV, M, SP and SK, which are epistemic and cognitive aspects of science, are included more than social categories. Apart from this, teachers generally suggested giving examples from the history of science mostly to teach social categories of science, technology integration such as video links, organization link, increasing the number of the activities such as observation, experiment, discussion, questioning, working in a group, and theater, adding knowledge boxes and current news in science textbooks.

Apart from that, some of the teachers explained that SE and SV need not be included in the science textbooks, it is the teacher's duty to teach these concepts. Also, many teachers stated that although FS and PPS are not included in the textbooks, it is not necessary to include these subjects openly to middle school students' science textbooks.

Finally, there are also teachers who mentioned that it is an unrealistic request to include all the nature of science categories in the science textbooks with rich content due to the very intense curriculum. Most of the participants stated that they need a teacher

guidebook that contains directions on how to teach the nature of science, even if it is not in the textbooks, to guide the teacher on this subject.

5. DISCUSSION

This chapter includes discussion of the results, implications, limitations and future studies. In the first section, theoretical background, significance and methodology of the study are outlined. In the second section, the results of the study are interpreted and their alignment with the previous studies are discussed. In the third section, implications for teaching, learning and different stakeholders are explained. In the last part, the limitations of the study are presented to light the way for future studies.

5.1. Discussion of the Results

In this section the results and their alignments are discussed with the light of the previous studies under 2 subsections for content analysis of the science textbooks and science teachers' perceptions on NOS and science textbooks. The first subsection includes the discussions on content analysis in terms of epistemic and cognitive aspects of science, social-institutional aspects of science and science, engineering and entrepreneurship applications. The second subsection discussed teacher understanding and perceptions of NOS, science teachers' perceptions towards using the science textbooks, and science teachers' perceptions and suggestions on representation of NOS in the science textbooks.

5.1.1. Content Analysis of the Science Textbooks

The results show that the total of 196 codes from the 5th-grade science textbook, 545 from the 6th-grade science textbook, 284 from the 7th-grade science textbook and 427 from the 8th-grade science textbook were found. One of the reasons why there are so many codes in each textbook may be that the frequency of the codes under the "Scientific Practices" in each textbook are so much. Also, the number of the pages of the science textbooks may be one of the reasons why the total code has such different values. Considering the total number of pages, it is seen that the 5th-grade science textbook has the least number of pages, and the 6th-grade has the highest number of pages. The high number of codes is not a sufficient

criterion to comment that a textbook represents the NOS well. Their inclusion and depths should be considered to say that the textbook represent the NOS well or not.

When looking at which units there are more codes in the science textbooks, the fact that the number of codes is less or more could not be associated with physics, chemistry and biology subjects. Units with a high number of codes in 5th, 6th, and 8th-grade science textbooks are the units with a high number of objectives and lesson hours in the science curriculum (Milli Eğitim Bakanlığı [MEB], 2018), while units with a small number of codes in the science curriculum are units with fewer objectives and lesson hours in the science curriculum (MEB, 2018). On the contrary, the unit with the highest number of codes in the 7th-grade science textbook is the unit with the least number of objectives and lesson hours in the science curriculum (MEB, 2018). The reason may be that physics topics includes more experiments and activities in the 7th-grade science textbook. The codes under content, activity and assessment sections indicates that activity sections include more codes than other section. Especially, SP, M, SCD and PA categories were found mostly in the activity sections in each science textbook. Other social categories of science were not included sufficiently in the activity parts of the textbooks. This result is in line with the results of the study conducted by Park *et al.* (2020). The results also indicated that the articulation of the NOS ideas occurring both vertically (across all grade levels) and horizontally (within science topics) were not seen in any science textbooks. However, it is important to consider the articulation of NOS for providing students to learn each aspects of NOS in each grade level across different science topics (Erduran & Dagher, 2014a).

5.1.1.1. Epistemic and Cognitive Aspects of Science. “Aims and values (AV)”, “scientific practices (SP)”, “methods and methodological rules (M)”, and “scientific knowledge (SK)” are the epistemic and cognitive aspects of science. The results indicate that AV is not represented adequately in the 5th, 6th, 7th and 8th-grade science textbooks. When the science textbooks are compared among themselves, it can be said that aims and values of science are better represented with codes such as medical treatment, raising public awareness, ease of life, empirical adequacy and critical examination in the 6th and 7th-grade science textbooks. This result is in line with the study of BouJaoude *et al.* (2017) resulting that the examined textbook focuses almost merely on the utility of science to develop human lives through some discoveries or technological advancements.

Even though there are some codes for AV, there are not enough statements referring that these are aims or values of science. Although the aims of science were clearly mentioned in the science curriculum in 2006 and 2013 (Kaya & Erduran, 2016), the aims of science were not explicitly stated in the science textbooks. However, many scientific studies were mentioned in the context of the subject and their importance was emphasized. These examples may allow students to learn implicitly what the aims of science are. This result is in line with the McDonald's (2017) study examining the representation of NOS in Australian science textbooks and resulting that there was no reference to the aims and values category in examined textbooks. Some other epistemic and cognitive aims and values of science which are mentioned by Erduran and Dagher (2014a) such as objectivity, novelty and accuracy and some social values like decentralizing power, honesty or equality of intellectual authority could be integrated into content, activities and assessment sections equally to teach epistemic cognitive and social aims and values of science.

When the science textbooks are examined, it is seen that the most codes and highlights in all textbooks were found in the “scientific practices (SP)” category. All the textbooks contain different activities such as doing experiment, doing models, let's research, let's discuss etc. When these activities are examined, many SPs defined by RFN have been found in all examined science textbooks. There are many scientific inquiry activities in every textbook that encourage students to collect data, reach a conclusion and explain it based on these data, as well as encourage students to share the information they have obtained as a result of their discussion and research with their friends. However, some of the SPs were generally represented as isolated activities, and the practices generally were given as recipe. McDonald (2017) also found similar findings for SP category in the examined textbooks.

In addition, many of the SPs mentioned in the 2006 and 2013 science curricula (Kaya & Erduran, 2016) are seen in the science textbooks and it can be said that there is a strong link between the results of these two studies for the SP category. Considering the other categories, it can be said that there are mostly examples of SP categories in integrating the nature of science into science education. However, Kaya and Erduran (2016) argue that although epistemic practices such as observation, classification and experimentation are emphasized in science classes in schools, their role in the production and development of

scientific knowledge is not sufficiently discussed. This is also the case for the textbooks that have been analyzed in the current study. For example, there are many statements in the textbooks that scientists classify living things, elements, etc. and there are some classification activities in the textbooks. In the textbooks, classification is just an activity to organize something given according to their common characteristics without drawing attention to any epistemic, cognitive, or social aspect of science. However, the classification made by scientists includes not only organizing observations based on existing relationships, but also predicting the place of subsequent observations or objects in specified categories in a theoretical framework (Kaya & Erduran, 2016).

Besides, students can start to think about each subject and example from real life which are presented in the textbooks. However, the science textbooks are insufficient in terms of establishing links between real life examples and practices. For example, after an example of daily life is given on a subject, instead of having an experiment, observation or research based on that example, an independent activity is mostly done. This link can be presented more strongly.

“Methods and methodological rules (M)” are the variety of systematic approaches and the rules that scientists use to reach reliable knowledge. The results indicate that M category is not well represented in any examined science textbooks. According to Allchin (2014), scientific inquiry activities should encourage students to assess the quality of evidence, argue about alternative models, have a consensus about one of them, and differ interpretations of data. Although scientists use different methods such as observing, collecting the data, comparing the results, measuring, testing, and constructing theories etc. there is no exact sequence of steps that is followed by scientists (Lederman *et al.*, 2002). Since, it is not correct to mention one scientific method that assures reaching unfailing knowledge (Bauer, 1994; Feyerabend, 1993). However, in scientific inquiry activities in the examined science textbooks, students are asked to do activities step by step, and come to a conclusion. For example, textbooks do not allow students to reach the conclusion that they need to design an experiment to look for an answer to a question, and meanwhile, to create the experiment setup using the materials they want. The textbooks tell the order in which to conduct the experimental setup, and even they sometimes direct students what result they reach.

Although the textbooks do not explicitly mention the hypothesis in the 6th and 7th-grade textbooks, it is said that the following activity will be done to find the answer to that question by asking students a question before each scientific inquiry activities. In addition, in the results section of some of the scientific inquiry activities such as experiments and observations in the 6th-grade textbook, students are recommended to do the same activity using different materials. At the same time, it directs the student to the scientific research processes page given at the beginning of the textbook after each activity. Some of the different branches of science are mentioned in the 6th, 7th and 8th-grade but domain general and domain specific features of those branches are not explained in any textbooks. Scientific methods such as testing hypothesis, manipulative testing is given implicitly in all examined textbooks. However, it is not mentioned that these are one of the methods in science.

The findings showed that the textbooks do not ease students to understand non-experimental method is as valuable as experimental one. However, the students would understand scientists who study on astronomy do not conduct experiment by manipulating objects on space, but they still construct and test hypothesis without using experimental methods to obtain knowledge (Erduran & Dagher, 2014a).

Some of the features of “scientific knowledge (SK)” and development of SK are represented well with the examples from the history of science in the 5th, 6th, 7th and 8th-grade science textbooks well. This result is in line with the study of Vesterinen *et al.* (2013) which concluded that the tentative nature of scientific theories is the most common aspect of NOS emphasized in Finnish and Swedish science textbooks. In addition, in the science curricula of the years 2006 and 2013 (Kaya & Erduran, 2016), emphasis has been placed on the development and tentative nature of scientific knowledge in general. As a result of this study, it can be said that there is sufficient emphasis on these aspects of scientific knowledge in the examined science textbooks. In addition, students can be encouraged to do activities for the development of scientific knowledge, even if they are presented with many examples in the content sections of the textbooks.

On the contrary, in the 5th, 6th, 7th and 8th-grade science textbooks, there are not adequate references to law, model and theory which are types of SK, emerge as products of the scientific enterprise with the contribution of SP and M (Erduran & Dagher, 2014a; Giere,

1991). Although there are a lot of model images (e.g., solar system model, DNA model, etc.) in the textbooks, the emphasis that they are models is very limited. The results indicate that the textbooks are inadequate to portray the TLM is a type of scientific knowledge which work together for development of scientific knowledge and contribute to explain a specific topic in a different field of science (Erduran & Dagher, 2014a). Although the names of some theories and laws are mentioned in the textbooks, it is not mentioned that they one of the types of scientific knowledge and that they support each other. In summary, even though there are many references on the epistemic and cognitive aspects of science in the science textbooks it cannot be said that none of the textbooks represent the epistemic and cognitive aspects of science which are AV, SP, M and SK well within the theoretical framework which is RFN.

5.1.1.2. Social-Institutional Aspects of Science. Woodcock (2014) defines science as a social enterprise. Science cannot intrinsically be considered apart from the social and cultural system which include social values, particular activities, social communities and institutions (Erduran & Dagher, 2014a). Understanding the nature of science requires to comprehend that science is socially structured and validated (Driver *et al.*, 1994; McComas, 2006; Ziman, 1987). “Social Certification and Dissemination (SCD)”, “Professional Activities (PA)”, “Scientific Ethos (SE)”, “Social Values (SV)”, “Social Organizations and Interactions (SOI)”, “Financial Systems (FS)” and “Political Power Structures” are the social-institutional categories of science.

“Social certification and dissemination (SCD)” is one of the most well represented social category of science in the 5th, 6th, 7th, and 8th-grade science textbooks. In the content sections of the textbooks there are very limited references to SCD but in the activity sections students are encouraged to share their findings with their peers by presentation, exhibition in different channels. Even though dissemination and dissemination channels are well represented in the activity sections, the content sections can be revised to be included some references to SCD contains sharing results of the studies at conferences, generating manuscripts of studies and publishing them in particular journals by scientists (Irzik & Nola, 2014; Kitcher, 2011).

Besides, “professional activities (PA)” is another well represented social category in all examined science textbooks. Similar finding was also reported by McDonald (2017) who examined representation of NOS in Australian junior secondary school textbooks. Even though in the 2006 and 2013 science curricula there is no references to PA category (Kaya & Erduran, 2016), all textbooks encourage students to share their findings, participate in science fests, work in a group, and prepare projects and reports. Although students are allowed to experience professional activities such as sharing the results with many activities, the explicit emphasis on the professional activities of scientists in the content sections is almost non-existent and superficial in the 5th, 6th, and 8th-grade science textbooks. The variety of the PA such as attending in conferences, seeking for funding resources, preparing proposals, publishing articles and peer-reviewing, supervising employees (Irzik & Nola, 2014; Woodcock, 2014) are lack of in the examined textbooks. On the contrary, the 7th-grade science textbook represents the PA category better in both activity and content sections. In this textbook, examples of scientists from different nations are presented and the characteristics that scientists should have are also emphasized.

“Social values (SV)” which are the compounds of RFN framework including respect for environment, social utility and freedom (Erduran & Dagher, 2014a; Irzik & Nola, 2014) and “scientific ethos (SE)” which are defined as norms and rules expected to be adopted by scientists during scientific investigations and interactions with their colleagues (Erduran & Dagher, 2014a; Irzik & Nola, 2014) are the one of the least represented social categories of science. The results for these categories are also in line with the Kaya and Erduran’s (2016) study examining 2006 and 2013 science curricula.

All examined science textbooks generally include social utility as a social value. Additionally, in the lab safety section of the 6th-grade science textbook there are some explicit references to animal care and respect to environment, but the number of the references can be increased and outspreaded throughout the units. The textbooks lack of many social values and norms such “honesty, carefulness, objectivity, openness, freedom, credit, respect for intellectual property, respect for colleagues and student, respect for research subjects, competence, confidentiality, legality, stewardship of resources” (Resnik, 2007, p.45-48). The social values such as respect for environment, animal care, freedom, ideological constraints might be seen different topics than science topics by textbook authors

and so they may not integrate them in science contents. However, the scientifically literate students should be aware that they do not harm any creature and feel free regardless of their ideologies while conducting scientific investigations.

“Social organizations and interactions (SOI)” are not well represented in the 5th, 6th and 8th-grade but in the 7th-grade there are many references to SOI such as laboratories, science centers, schools, some scientific organizations such as NASA and TÜBİTAK. However, the interactions among the social organizations and the members in those organizations are not given in the 5th, 6th, 7th and 8th-grade science textbooks. “Financial systems (FS)” and “political power structures (PPS)” are not represented adequately in the textbooks. There are hardly ever references to need for money in the 6th-grade and investment need in the 8th-grade, national economic benefit in the 7th-and 8th-grade science textbooks. There is also commercialization example from the 5th-grade science textbook. Also, for the PPS there are only international cooperation and government support references found in all textbooks. The representation of those categories is totally insufficient to teach how those categories affect science.

The social categories of science are not included adequately in the examined science textbooks. These results are in line with many studies conducted to examine the representation of NOS (Abd-El-Khalick *et al.*, 2008; Esmer, 2011; Irez, 2009; Ramnarain & Chanetsa, 2016; Wei *et al.*, 2013; Yamak, 2009). The reason why these categories are so lacking in the textbooks may be some ideas of science educator and textbook authors. They may think that social aspects of science cannot be linked to science subjects, or they thought that middle school students do not need to learn these categories and teaching social aspects of science may bring a high cognitive load. The social institutional aspects of science should be integrated in science education holistically to capture the relations among the compounds of science and their impacts on growth of scientific knowledge. Hence, the textbooks should include all categories of science equally to show their importance and connections.

5.1.1.3. Science, Engineering, Entrepreneurship Applications (SEEA). One of the sections in which the nature of science is expected to be emphasized is the science, engineering, and entrepreneurship applications (SEEA) in the first pages of the textbooks. This section includes some naïve understanding about some of the categories of RFN. The 5th-grade

science textbook emphasizes that engineers use design loop steps and scientific research steps for their studies. There is no emphasizes on science and scientists. In the 6th and 7th-grade science textbook scientific research process and engineering design process are given separately but they are given step-by-step directions to build model and reach a conclusion from scientific investigation or engineering work. Most of the engineering design process are given in the textbooks like this and engineering principles are supported with scientific methods as a step-by-step process (Cantrell & Robinson, 2002).

The 8th-grade science textbook does not include SEEA at the beginning of the textbook, but it includes at the end of each unit by referring the design loop steps. It can be said that at the end of each unit in the 8th-grade science textbook there are examples from history of science which talk about the scientists, their investigations and development of SK. After each story, the students are asked that why they think the people who are mentioned above need to develop a product. Then, students are encouraged to find daily life problems related to the subjects given in the unit and design a product by following design loop steps. This result is in line with the Cantrell and Robinson's (2002) study showing that textbook have sections addressing STEM and society. These stories generally talk about the life of the scientists and their works to emphasis the need for formation of discoveries and scientific knowledge explicitly.

Even though 5th-grade science textbook does not mention the science and scientists, it explains the scientific research steps. In there, students are encouraged to specify daily life problem and research about the problem from different resources. Then students are asked to list possible solutions for problem and select most appropriate methods such as experiment, observation or other methods to test their solution and report it. The M category is represented well in this section because it aims to teach that there can be many solutions for one problem and different methods can be used to solve it. This result is in line with the Niaz and Maza's (2011) study showing some of the examined science textbooks presented scientific method satisfactorily.

However, in the 6th-grade science textbook there is a naïve understanding about M. In the scientific research process, it gives some steps to be followed by students such as specifying problems, research, hypothesis construction, doing experiment and result of

experiment. This may cause student to think that there is only one way to solve problems in science and they must construct hypothesis and test it by just doing experiment. On the other hand, this is the only textbook linking the activity of the scientists and students for the SCD and PA categories explicitly.

7th-grade science textbook defines science by highlighting credible nature of SK, critical examination and empirical adequacy. As in the 6th-grade textbook, naïve understanding is displayed in the 7th-grade textbook while giving scientific research steps. It seems that ideas of step-by-step methods and one universal scientific method continue in the textbooks although this thought has been debunked. This situation also continues in the high school science textbooks (Abd-El-Khalick *et al.*, 2008). Niaz (2017) also argued that flow diagrams of scientific methods are common in the science textbooks and this is problematic. Also, the textbooks still implicitly present more narrow and traditional view about scientific methods (Binns & Bell, 2015). Also, Irez (2009) who analyzed the depiction of NOS in Turkish high school biology textbooks found that authors of the textbooks generally do not understand the process of scientific works and they mention scientific methods step by step.

Except for the step-by-step methods and the perception that there is only one scientific method, this section is better prepared in terms of social categories in the 7th-grade science textbook than other textbooks. It is mentioned that scientists and engineers work together and carry out studies that contribute to humanity. At the same time, an activity was given to students at 4 stations on how to follow the design cycle and scientific research processes. Besides, in this section, the life of the Turkish scientist Aziz Sancar is explained, and here the features that a scientist should have, the need for scholarship, Nobel Prize, benefit to humanity and the country are mentioned.

In each science textbook, students are encouraged to design a model, test it and share their models in different platforms with others. Also, in each textbook emphasize that while designing products, budget planning was required. Even though 7th- grade science textbook includes more references to social aspects of science, still there is a need to integrate SE, SV, SOI, FS and PPS in SEEA sections in each textbook. This is in line with the Alpaslan, Yalvac and Loving's (2015) study indicating that there is a little emphasis on social aspects of science in the STEM textbooks.

5.1.2. Science Teachers' Perceptions on NOS and Science Textbooks

This subsection includes discussions on the teacher understanding and perceptions of NOS, science teachers' perceptions towards using the science textbooks, and science teachers' perceptions and suggestions on representation of NOS in the science textbooks.

5.1.2.1. Discussion of the Teachers' Understanding and Perceptions of NOS. Although many studies show that teachers have low and naïve understanding of NOS (Abd-El-Khalick, 2001; Akerson & Hanuscin, 2007; Akerson *et al.*, 2000; Lederman *et al.*, 2012; Morrison *et al.*, 2009) the current study shows that, on the contrary, teachers' have high NOS level. The quantitative results showed that participants who are the science teachers have high NOS level for each category of science, but interview results indicated that some of the participants have some naïve understanding about “scientific practices (SP)”, “methods and methodological rules (M)” and “professional activities (PA)”. Also, some of them did not elaborate their ideas about “political power structures (PPS)”. The analysis results indicated that teachers' perceptions and understanding about NOS do not change according to their teaching experiences, school types and gender. The similar result was found for “aims and values (AV)”, “social-institutional aspects (SI)” and “educational application (EA)” by Aksoz (2019).

It was found that most of the teachers perceived AV by understanding the universe, serving to humanity, development of technology and empirical adequacy and some of them talked about the social utility, animal care, and respect for environment, intellectual honesty, decentralizing power and doing no harm as values of science. The findings are in line with the some of the studies conducted based on RFN to examine preservice science teachers, in service teachers and university students' perceptions of NOS (Akgun & Kaya, 2020; Aksoz, 2019; Kaya *et al.*, 2019). Even though all teachers are aware of the “Methods and Methodological Rules (M)”, they hardly ever mentioned non-manipulative and non-hypothesis methods. In a study conducted to examine the students' understanding of RFN, it was seen that students did not emphasize non-manipulative and non-hypothesis methods (Cilekrenkli, 2019). This is linked to the teachers' results. Also, most of the teachers talked about the step-by-step scientific research process which are also mentioned in the examined science textbooks. When teachers were asked about the “scientific practice (SP)” most of

the teachers exhibited naive understandings. The reason for this may be that the word practice in Turkish means easy to apply and convenient. Another reasons why teachers cannot deepen scientific practices and distinguish them from methods may be the content of the courses they took at the university. Saribas and Ceyhan (2015) suggested that integrating scientific practices component of the NOS in pre-service teacher education programs contributed their holistic understanding about scientific practices and eliminate some misconceptions. Teachers emphasized with many examples that “scientific knowledge (SK)” can improve and change. However, they never touched upon the laws, laws and models, which are types of SK. This may be because theory, law, and model that are generally not emphasized in schools as types of SK. Another study found a similar result for this category (Aksoz, 2019). Teachers have really good perceptions in social-institutional categories. This may be because they follow current issues in the world closely. While talking about SE, SV, SCD, SOI, FS and PPS, they expressed their perceptions by giving many examples from history and today. While explaining the PA category, only some teachers emphasized that the daily life of scientists and other people is not different. This may be due to the fact that the word activity also means daily work in Turkish.

Although teachers seem to have a good understanding in many categories, the emphasis on NOS should be made more explicit in in-service professional development trainings or teacher preparation programs in order to further increase understanding for each category. When teachers are asked what they are doing to teach NOS, most of them cited a series of experiments, observations, and activities they do in classes. However, they lack awareness that the NOS consists of many categories and that a holistic understanding can be achieved by integrating each of them into the lessons. Hence, teachers need to improve their both understanding and strategies to teach NOS. It is necessary to train students as scientifically literate (Tuan & Chin, 1999).

5.1.2.2. Discussion of the Teachers’ Perceptions of Using Science Textbooks. Almost all of the teachers said that they used science textbooks for some purposes such as examining the subjects, giving homework and checking the objectives in the preparation for the lesson. There was also some consensus of the current findings and previous research related to usage of science textbooks and their purposes to use textbooks. (Chambliss & Calfee 1998; Chiappetta *et al.*, 1991; Lumpe & Beck 1996; Martínez-Gracia *et al.*, 2006; Spiegel &

Barufaldi, 1994; Stern & Roseman, 2004; Weiss *et al.*, 1989). In current study, most of the teachers stated that they do not use science textbooks given by Ministry of National Education (MoNE) in their lessons because they do not include various real-life examples, they do not trigger curiosity, do not allow students to use different methods and do not contain NOS categories, they include some misconceptions related to science topics and do not include high ability questions. Some of the previous studies also found that teachers do not prefer to use science textbooks because of the similar reasons exist in this study (e.g., Eyidoğan & Güneysu, 2002; Kook, 2003; Pizzini, 1992; Shepardson & Pizzini, 1991; Vasconcelos *et al.*, 2012).

When the teachers were asked whether they used alternative textbooks, one teacher said that they used different textbooks because the language of instruction was English, but the rest of the teachers stated that they used alternative question and lecture books rather than the textbook. Teachers mentioned the same reasons about why they do not use science textbooks given by MoNE and why they use alternative books. Besides, almost all mentioned that the textbooks do not prepare students for the high school entrance exam and they have to solve a lot of questions to prepare for that exam. These results are also in line with a study examining the opinions of middle school science teachers about their desire to use alternative books and supplementary resources (Haşiloğlu *et al.*, 2020).

Although the teachers emphasized the importance of teaching NOS in science lessons, they mentioned that they could not adequately include NOS in their lessons due to issues such as time constraints, curriculum problems, and high school entrance exam. These problems, which are mentioned about not including NOS in science education, are similar to the study conducted with a different group of teachers (Aksoz, 2019). In addition, almost all of the teachers mentioned the science applications course, which is an additional elective course to the science courses in middle school. Although they stated that the content of the science applications course is very suitable for NOS, it was emphasized that in this elective course, students generally solve questions or only experimental and observation activities are carried out. In one of the previous studies, it was stated that the science applications course did not reach its purpose. Some of the problems such as the lack of a textbook for this lesson, the lack of training of the teachers about this lesson, and lack of time were cited as the reasons for this by the teachers (Bozdoğan *et al.*, 2014).

5.1.2.3. Discussion of the Teachers' Perceptions and Suggestions on Representation of NOS in Science Textbooks. Teachers' answers to whether there are RFN categories in science textbooks showed that the other categories except M are almost nonexistent in the textbooks. The teachers suggested similar things for integration of epistemic and cognitive categories of science which are AV, SP, M and SK. The teachers recommended that NOS can be taught to students by integrating history of science, technology (documentary links, and augmented reality application), set of activities (observation, experimentation, puzzles, reading passages), various real-life examples, questions, news related to current events, pictures and information boxes related to each category in science textbooks. Besides, for the integration of the social-institutional categories of science in science textbooks, teachers suggested that some activities (discussion, working in a group, theater), technology (link for social institutions such as TUBITAK, online zoos, scientific videos, and documentaries), history of science, news related to current events, photographs (conferences, scientists) and some expressions after activities such as exhibit, present, share can be integrated into science textbooks. There are grounds for many of the teachers' suggestions as an effective tool that can be used to teach NOS. Textbook questions are very essential to activate and direct to students learning (Overman *et al.*, 2013) so questions can contribute to students for understanding and thinking about some of the categories of NOS. Besides, Allchin (2014) suggests that NOS can be taught with the science inquiry activities, contemporary cases and historical vignettes. Especially historical cases can be used to teach SK and social dimension of science (Abd-El-Khalick & Lederman, 2000; Lederman, 2007; McDonald, 2017; Rudge & Howe, 2009).

Also, current and global events which are one of the socio scientific issues can be integrated into science lessons to teach most of the categories of science (Erduran & Dagher, 2014a). Besides, some of the participants thought that the nature of science can be integrated into all subjects and units of the textbooks, or it can also be given as introductory textbook chapter. However, this may cause students to not encounter any emphasis on NOS during the education period after reading introductory pages related to NOS. Erduran and Dagher (2014a) highlight the horizontal articulation of RFN categories to pursue a continuity of extent of RFN themes throughout the school year. Hence the textbooks may include all categories of science throughout the textbooks rather than in introductory chapters.

Some of the teachers supported that statements for the SE and SV categories do not have to be found in the textbooks. They mentioned that the teacher can individually draw attention to these issues in the lessons. Also, they thought that including some information and activities to teach these categories may inhibit to teach subjects in the curriculum. The reason they feel this way may be that the curriculum has a very dense subject content. Also, some of the teachers may think that young students can have a difficulty to understand the philosophical aspects of science such as SE, SV, AV (Jho, 2019). However, Erduran and Dagher (2014a) state that all categories of science should be taught to students, but their complexity level can be changed based on students' age or their readiness levels. RFN categories can be included in science lessons with different depths and different activities from kindergarten to high school. The important thing here is to integrate each category into the lessons without ignoring some of them (Erduran & Dagher, 2014a).

In addition, teachers stated that students can learn FS with the extracurricular projects while buying materials or applying to projects, so FS category does not have to be integrated in the textbooks. However, integrating FS in science lessons contribute to increase students' awareness on economics-related issues, contribute to social and economic development of a country and helps students to build connection between real life and everyday application of science (Kaya *et al.*, 2018). Also, in the 2018 Turkish Science Curriculum (MEB, 2018) importance of economics, ethics, social values have been emphasized so the textbooks should include them. Lastly, some of the teachers stated that the PPS category does not have to be taught to students via textbooks. The reason for this may be that the word politics evokes different meanings for teachers, and they may think that middle school students do not ready to learn something about PPS. However, in order to understand how science operates in society, students should be aware of SV, SE, FS and PPS categories of science.

Lack of need for categories such as SE, SV, FS and PPS to be included in the textbooks may lead to a lack of understanding and perception of students on these issues. If teachers do not understand the topic in depth, teacher cannot apply these topics in the classroom effectively. Therefore, integration of RFN into teacher education is very essential to make teachers feel knowledgeable about a topic (Kaya *et al.*, 2018). When teachers are aware of horizontal and vertical articulation of RFN categories across science topics and grade levels they can understand why it is important to teach all categories of RFN and how

they should be included in their lessons. Likewise, if authors give an importance on the articulation of NOS in the textbooks, students can better understand how science operates by making better sense of RFN categories.

5.2. Implications of the Study

The results of the current study are essential because the results provide remarkable data leading to many implications and recommendations for teaching, learning and different stakeholders. These implications can guide policy makers, publishers, and teachers to think about how to improve middle school science textbooks and how to integrate them in our science lessons to teach NOS.

Understanding of nature of science is essential for students to become scientifically literate individuals making better decisions about scientific issues (Lederman, 1999). Also, learning NOS is one of the essential aims of some science policy documents (MEB, 2018; NRC, 2012). Students are expected to graduate from middle school with having the NOS understanding. The textbooks are essential learning and teaching resources for both teachers and students. In this context, science textbooks can be used to learn NOS by students and to teach NOS by teachers. Although some codes belonging to each category of RFN, which emphasize epistemic cognitive and social aspects of science, have been identified in the middle school science textbooks, the keywords and highlights encountered in the textbooks are not sufficient to teach and learn NOS. The science curriculum and documents should provide explicit and detailed directions on how to teach NOS by using textbooks to provide effective NOS learning. The textbooks should include explicit references to each category of science in a balanced way by providing both vertical and horizontal articulation. In this way, students can have more sophisticated understanding of NOS ideas and they can improve the ability to transfer the information they learnt throughout the years into novel situations (Erduran & Dagher, 2014a).

The teachers in the current study stated that they do not use science textbooks to teach NOS because the textbooks do not emphasis on NOS explicitly. One of the studies examining the textbook usage of science teachers showed that most of the science teachers consider layout, color, illustrations, emphasis on science content, readability, alignment with

curriculum while selecting the textbooks (McDonald, 2016). Both of the studies indicate that teachers do not consider how the textbooks represent the NOS while choosing a textbook. Although the teachers in this study think that teaching NOS is very important, they do not think that their science textbooks are resources to teach NOS. Hence, the teachers should be aware about the inclusion of NOS in textbooks to teach NOS adequately to their students.

Interviews with teachers at the end of this study showed that teachers' perception and understanding of the nature of science were generally high. However, when asked how they included the nature of science in their lessons, they only talked about the activities such as experimenting and observing. This may indicate that although teachers have a high understanding of the nature of science, they do not have sufficient knowledge about how to integrate them into their lessons and how to use textbooks for this purpose. Hence, they can be educated to integrate NOS in their lessons effectively.

The teachers also said that if there is a textbook containing all the categories of NOS, they will use it actively in their lessons. In addition, the majority of teachers stated that even if the emphasis on NOS is insufficient in their textbooks, they need a teacher's guidebook that contains directions for teachers to integrate NOS in their lessons. When all these are considered, one of the most important criteria that policy makers should pay attention to in their selection of textbooks should be how much the textbooks contain and represent the nature of science. If policy makers take care to choose textbooks that represent NOS correctly and explicitly, publishers and authors may pay attention to this point and may organize the textbooks in this context.

Many of the teachers mentioned the elective science applications course. It was complained that the curriculum of this course is very suitable for teaching the nature of science, but there is no textbook and teacher material. For this course, a book can be designed in which RFN categories are directly emphasized, and in-service training can be given to teachers on how to integrate the content of the NOS and the activities in the textbook into the course.

The most repeated recommendation from teachers to teach NOS is different activities, sections from the history of science, video and website links to be integrated into

the textbooks. It is suggested that when writing the textbooks, authors should include content and activities that directly emphasize NOS. Different categories of NOS need to be integrated in every subject of the textbook by considering vertical and horizontal articulation of RFN categories across science topics and grade levels (Erduran & Dagher, 2014a). Thus, students can be aware of the NOS emphasis throughout the textbook. The generative images created for each RFN categories by Erduran and Dagher (2014a) can be integrated into science textbooks by considering the context and science topics to teach NOS explicitly. Based on the results of this study, it is also suggested that not only epistemic and cognitive but also social categories of science should be included in the textbooks with equal importance. If all these are fulfilled, teachers who use textbooks as primary sources can be able to use them in their lessons to teach the nature of science effectively.

5.3. Limitations and Future Research

Although this study serves to close a gap in the literature by examining the NOS representations based on RFN in Turkish science textbooks, the current study has some limitations that can be considered in the future studies.

Firstly, the current study just focused on the examination of the middle school science textbooks which were accepted as a science textbook for 2020-2021 education term by the Ministry of National Education (MoNE) of Turkey. There are multiple textbooks which are approved by MoNE to be science textbook for different grade levels. However, in the current study science textbooks published by private publishers were selected because of some criteria. In the future studies, other science textbooks which were approved by MoNE can be examined to detect representation of NOS and comparison between them can be done to detect best textbooks portraying NOS well. Besides, more studies need to be conducted to analyze primary school (3rd and 4th grade) science textbooks and high school science textbooks which are biology, chemistry and physics for the representation of NOS.

Secondly, 8 teachers were interviewed in the study. More teachers can be interviewed in the future studies. Although the results indicated that participants have a high perception of the nature of science in this study, middle school science teachers in different schools can be observed, with regard to their inclusion of the NOS. This is essential to notice which

factors affect teachers to teach NOS, whether if teachers present correct NOS understanding, and how they use textbooks to teach NOS.

Thirdly, the content analysis results were often compared with Turkish science curricula published in 2006 and 2013. However, textbooks started to be used after new science curriculum published in 2018. In order to present the current science curriculum and textbooks compatibility with regard to representation of NOS, science curriculum published in 2018 can be examined in the future studies.

Fourthly, surveys or interviews can be conducted with the science textbook authors to present their understanding of the NOS in the future studies. The findings obtained from these studies can be used to ensure that whether the textbook authors are well-versed on the RFN categories or not.

Fifthly, this study does not give much place to the opinions of the teachers about the elective science application course. However, as a result of the comments from the teachers, the curriculum of this course can be examined, and teacher interviews can be conducted on the representation of NOS based on RFN. Lastly, the keywords and codes can be used for future studies examining the representation of NOS in science textbook

REFERENCES

- Abd-El-Khalick, F. & Akerson, V.L. (2004). Learning about nature of science as conceptual change: Factors that mediate the development of preservice elementary teachers' views of nature of science. *Science Education*, 88, 785-810.
- Abd-El-Khalick, F., Bell, R. L., & Lederman, N. G. (1998). The nature of science and instructional practice: Making the unnatural natural. *Science Education*, 82, 417-436.
- Abd-El-Khalick, F. (2001). Embedding nature of science instruction in preservice elementary science courses: abandoning scientism, but... *Journal of Science Teacher Education*, 12(3), 215-233.
- Abd-El-Khalick, F. (2002). Images of Nature of Science in Middle Grade Science Trade Books. *New Advocate*, 15(2), 121-27.
- Abd-El-Khalick, F., & Lederman, N. G. (2000a). Improving science teachers' conceptions of nature of science: A critical review of the literature. *International Journal of Science Education*, 22(7), 665–701.
- Abd-El-Khalick, F., & Lederman, N. G. (2000b). The influence of history of science courses on students' views of nature of science. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, 37(10), 1057-1095.
- 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.

- 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.
- Akbayrak, M., & Kaya, E. (2020). Fifth-grade students' understanding of social-institutional aspects of science. *International Journal of Science Education*, 42(11), 1834-1861.
- Akerson, V. L., Abd-El-Khalick, F., & Lederman, N. G. (2000). Influence of a reflective explicit activity-based approach on elementary teachers' conceptions of nature of science. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, 37(4), 295-317.
- Akerson, V., & Donnelly, L. A. (2008). Relationships among learner characteristics and pre-service teachers' views of the nature of science. *Journal of Elementary Science Education*, 20(1), 45-58.
- Akerson, V. L., & Hanuscin, D. L. (2007). Teaching nature of science through inquiry: Results of a 3-year professional development program. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, 44(5), 653-680.
- Akgun, S., & Kaya, E. (2020). How do university students perceive the nature of science?. *Science & Education*, 29, 1-32.
- Aksoz, B. (2019). *The effects of pre- and in-service training on teachers' understanding of the nature of science* (Publication No. 582366) [Master thesis, Bogazici University]. Ulusal Tez Merkezi.
- Aleixandre, M. P. J., & Crujeiras, B. (2017). Epistemic practices and scientific practices in science education. *Science Education*, 69-80.

- Allchin, D. (2011). Evaluating knowledge of (whole) science. *Science Education*, 95(3), 518- 542.
- Allchin, D. (2014). From science studies to scientific literacy: A view from the classroom. *Science & Education*, 23(9), 1911-1932.
- Allchin, D. 1999. Values in science. *Science & Education* 8(1), 1–12
- Alpaslan, M. M., Yalvac, B., & Loving, C. C. (2015). Curriculum reform movements and science textbooks: A retrospective examination of 6th grade science textbooks. *EURASIA Journal of Mathematics, Science and Technology Education*, 11(2), 207-216.
- Alters, B. J. (1997). Whose nature of science??. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, 34(1), 39-55.
- American Association for the Advancement of Science [AAAS]. (1990). *Science for all Americans*. New York: Oxford University Press.
- 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.
- Azninda, H., & Sunarti, T. (2021). Teachers' views about nature of science (NOS) using reconceptualised family resemblance approach to nature of science (RFN) questionnaire. *Journal of Physics: Conference Series*, 1747.
- Banilower, E. R., Smith, P. S., Weiss, I. R., Malzahn, K. A., Campbell, K. M., & Weis, A. M. (2013). *Report of the 2012 national survey of science and mathematics education*. Chapel Hill, NC: Horizon Research.

- Barba, R.H., Pang, V.O., & Santa Cruz, R. (1993). User-friendly text. *Science Teacher*, 60(5), 15- 17.
- Barnes, S. B., & Dolby, R. G. (1970). The scientific ethos: A deviant viewpoint. *European Journal of Sociology/Archives Européennes de Sociologie/Europäisches Archiv für Soziologie*, 11(1), 3-25.
- Bauer, H. H. (1994). *Scientific literacy and the myth of the scientific method*. Champaign, IL: University of Illinois Press.
- Bayrakçı, M. (2005). Ders kitapları konusu ve ilköğretimde ücretsiz ders kitabı dağıtımı projesi. *Millî Eğitim Dergisi*, 165, 7-20.
- Bianchini, J.A. & Colburn, A. (2000). Teaching the nature of science through inquiry to prospective elementary teachers: A tale of two researchers. *Journal of Research in Science Teaching*, 37(2), 177-209.
- Binns, I. C., & Bell, R. L. (2015). Representation of scientific methodology in secondary science textbooks. *Science & Education*, 24(7), 913-936.
- BouJaoude, S., Dagher, Z. R., & Refai, S. (2017). The portrayal of nature of science in Lebanese ninth grade science textbooks. In C. V. McDonald & F. Abd-El-Khalick (Eds.), *Representations of nature of science in school science textbooks* (pp. 79-97). New York: Routledge.
- Boyatzis, R. E. (1998). *Transforming qualitative information: Thematic analysis and code development*. Sage Publications, Inc.
- Bozdoğan, B., Bozdoğan, A. E., & Şengül, Ü. (2014). Bilim uygulamaları dersi ile ilgili öğretmen görüşlerinin farklı değişkenler açısından incelenmesi. *Mersin Üniversitesi Eğitim Fakültesi Dergisi*, 10(3), 96-109.

- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101.
- Burnard, P. (1991). A method of analyzing interview transcripts in qualitative research. *Nurse Education Today*, 11(6), 461-466.
- Brunner, J. L., & Abd-El-Khalick, F. (2017). Representations of nature of science in US elementary science trade books. In C. V. McDonald & F. Abd-El-Khalick (Eds.), *Representations of nature of science in school science textbooks* (pp. 135-151). New York: Routledge.
- Bybee, R. W. (2011). Scientific and engineering practices in K-12 classrooms. *Science Teacher*, 78(9), 34-40.
- 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.
- Cantrell, P., & Robinson, M. (2002). How do 4th through 12th grade science textbooks address applications in engineering and technology?. *Bulletin of Science, Technology & Society*, 22(1), 31-41.
- Carrier, M. (2013). Values and objectivity in science: Value-ladenness, pluralism and the epistemic attitude. *Science & Education*, 22(10), 2547–2568.
- Central Association for Science and Mathematics Teachers. (1907). A consideration of the principles that should determine the courses in biology in secondary schools. *School Science and Mathematics*, 7, 241–247.
- Chambliss, M. J., & Calfee, R. C. (1998). *Textbooks for learning: Nurturing children's minds*. Malden, MA: Wiley.

- Chang, Y. H., Chang, C. Y., & Tseng, Y. H. (2010). Trends of science education research: An automatic content analysis. *Journal of Science Education and Technology*, 19(4), 315-331.
- Chiappetta, E. L., & Koballa, T.R. (2002). *Science instruction in the middle and secondary schools* (5th ed.). Upper Saddle River, NJ: Prentice Hall.
- Chiappetta, E.L., Sethna, G.H., & Fillman, D.A. (1991). A method to quantify major themes of scientific literacy in science textbooks. *Journal of Research in Science Teaching*. 28(8), 713-725.
- Chiappetta, E.L., Sethna, G.H., & Fillman, D.A. (1993). Do middle school life science textbooks provide a balance of scientific literacy themes? *Journal of Research in Science Teaching*, 30(7), 787-797.
- Chinn, C., & Malhotra, B. (2002). Epistemologically authentic inquiry in schools: A theoretical framework for evaluating inquiry tasks. *Science Education*, 86(2), 175–218.
- Christie, M., & Christie, J. (2003). Chemical laws and theories: A response to Vihalemm. *Foundations of Chemistry*, 5(2), 165–174.
- Cilekrenkli, A. (2019). *Teaching reconceptualised family resemblance approach to nature of science in lower secondary classrooms* (Publication No. 603292) [Master thesis, Bogazici University]. Ulusal Tez Merkezi.
- Collette, A. T., & Chiappetta, E. L. (1984). *Science instruction in the middle and secondary schools*. The CV Mosby Company, 11830 Westline Industrial Drive, St. Louis, MO 63146.
- Council for Science and Technology (CST). (2000). *Science teachers: A report on supporting and developing the profession of science teaching in primary and secondary schools*. London: Her Majesty's Stationery Office.

- Creswell, J. W. (2002). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. Upper Saddle River, NJ: Pearson Education.
- Creswell, J. W. (2007). *Qualitative inquiry and research method: Choosing among five approaches* (2nd. ed.). Thousand Oaks, CA: Sage.
- Cullinane, A. (2018). *Incorporating nature of science into initial science teacher education* (Unpublished doctoral dissertation). University of Limerick, Ireland.
- Dagher, Z., & BouJaoude, S. (2005). Students' perceptions of the nature of evolutionary theory. *Science Education*, 89(3), 378–391.
- Dagher, Z. R., & Erduran, S. (2017). Abandoning patchwork approaches to nature of science in science education. *Canadian Journal of Science, Mathematics and Technology Education*, 17(1), 46-52.
- Dagher, Z. R., & Erduran, S. (2016). Reconceptualizing the nature of science for science education: Why does it matter? *Science & Education*, 25(1-2), 147–164.
- Demir, N., & Akarsu, B. (2018). Ortaokul öğrencilerinin bilimin doğası hakkında algıları. *Journal of European Education*, 3(1).
- Denzin, N. K., & Lincoln, Y. S. (2005). The discipline and practice of qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (3rd ed., pp. 1-32). Thousand Oaks, CA: Sage.
- Devetak, I., & Vogrinc, J. (2013). The criteria for evaluating the quality of the science textbooks. In M. S. Khine (Eds.), *Critical analysis of science textbooks* (pp. 3-15). Springer, Dordrecht.
- DiGiuseppe, M. (2017). Improving representation of nature of science in textbooks through action research. In C. V. McDonald & F. Abd-El-Khalick (Eds.), *Representations*

of nature of science in school science textbooks (pp. 152-169). New York: Routledge.

Driver, R., Asoko, H., Leach J., Mortimere, M. & Scott, P. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher*, 23(7), 5-12.

Driver, R., Leach, J., Millar, R., & Scott, P. (1996). *Young people's images of science*. McGraw-Hill Education (UK).

Duschl, R., & Grandy, R. (2011). Demarcation in science education: Toward an enhanced view of scientific method. In R. Taylor & M. Ferrari (Eds.), *Epistemology and science education: Understanding the evolution vs. intelligent design controversy* (pp. 3–19). New York: Routledge.

Duschl, R. (1990). *Restructuring science education: The importance of theories and their development*. New York: Teacher's College Press.

Elgar, A. G. (2004). Science textbooks for lower secondary schools in Brunei: Issues of gender equity. *International Journal of Science Education*, 26(7), 875-894.

El-Mehtar, N., & Alameh, S. (2017). An analysis of the representation of nature of science in a chemistry textbook in the International Baccalaureate Diploma Program. In C. V. McDonald & F. Abd-El-Khalick (Eds.), *Representations of nature of science in school science textbooks* (pp. 170-187). New York: Routledge.

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing*, 62(1), 107-115.

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

- Erduran, S., & Dagher, Z. R. (2014b). Regaining focus in Irish junior cycle science: Potential new directions for curriculum and assessment on nature of science. *Irish Educational Studies*, 33(4), 335–350.
- Erduran, S., Kaya, E., & Dagher, Z. R. (2018). From lists in pieces to coherent wholes: Nature of science, scientific practices, and science teacher education. In J. Yeo, T. W. Teo, & K. S. Tang (Eds.), *Science education research and practice in Asia-Pacific and beyond* (pp. 3–24). Singapore: Springer.
- Erduran, S., Kaya, E., Cilekrenkli, A., Akgun, S., & Aksoz, B. (2020). Perceptions of nature of science emerging in group discussions: A comparative account of pre-service teachers from Turkey and England. *International Journal of Science and Mathematics Education*, 1-22.
- Erduran, S., & Mugaloglu, E. (2013). Interactions of economics of science in science education and implications for science teaching and learning. *Science & Education*, 22(10), 2405–2425.
- Eshach, H., & Fried, M. N. (2005). Should science be taught in early childhood? *Journal of Science Education and Technology*, 14(3), 315-336.
- Esmer, F. (2011). *Exploring representation of nature of science aspects in 9th grade chemistry textbooks* (Publication No. 286229) [Master thesis, Middle East Technical University]. Ulusal Tez Merkezi.
- Eyidoğan, F. & Güneysu, S. (2002). *İlköğretim 8. sınıf fen bilgisi kitaplarındaki kavram yanlışlarının incelenmesi*. V. Fen Bilimleri ve Matematik Eğitimi Kongresi, Ankara, Türkiye.
- Feyerabend, P. (1993). *Against method*. New York: Verso.
- Fontana, A., & Frey, J. H. (2000). The interview: From structured questions to negotiated text. *Handbook of Qualitative Research*, 2(6), 645-672.

- Garcia, T. D. (1985). *An analysis of earth science textbooks for presentation of aspects of scientific literacy* [Unpublished doctoral dissertation]. University of Houston: TX.
- Gibbs, A., & Lawson, A.E. (1992). The nature of scientific thinking as reflected by the work of biologists and by science textbooks. *The American Biology Teacher*, 54(3), 137-152.
- Giere, R. (1991). *Understanding scientific reasoning* (3rd ed.). Fort Worth, TX: Holt, Rinehart and Winston, Inc.
- Graneheim, U. H., & Lundman, B. (2004). Qualitative content analysis in nursing research: Concepts, procedures, and measures to achieve trustworthiness. *Nurse Education Today*, 24(2), 105-112.
- Guba, E. G., & Lincoln, Y. S. (1982). Epistemological and methodological bases of naturalistic inquiry. *Educational Communication and Technology Journal*, 30(4), 233-252.
- Harding, S. G., & Hintikka, M. (Eds.). (1983). *Discovering reality: Feminist perspectives on epistemology, metaphysics, methodology, and philosophy of science*. Dordrecht, The Netherlands: Reidel.
- Haşiloğlu, M. A., Güler, H., & Durmaz, E. (2020). Ortaokul sosyal bilgiler ve fen bilimleri öğretmenlerinin yardımcı kitap kullanma nedenleri ile ilgili görüşleri. *Ekev Akademi Dergisi*, 83, 565-577.
- Holbrook, J., & Rannikmae, M. (2007). The nature of science education for enhancing scientific literacy. *International Journal of Science Education*, 29(11), 1347-1362.
- Irez, S. (2009). Nature of science as depicted in Turkish biology textbooks. *Science Education*, 93(3), 422-447.

- Irzik, G., & Nola, R. (2011). A family resemblance approach to the nature of science. *Science & Education*, 20(7), 591–607.
- 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). Dordrecht, The Netherlands: Springer.
- Jho, H. (2019). A comparative study on the various perspectives on the nature of science through textbook analysis centering on the consensus view, features of science, and family resemblance approach. *Journal of the Korean Association for Science Education*, 39(5), 681-694.
- Jonas, H. (1969). Philosophical reflections on experimenting with human subjects. *Daedalus*, 98(2), 219–247.
- Kahveci, A. (2010). Quantitative analysis of science and chemistry textbooks for indicators of reform: A complementary perspective. *International Journal of Science Education*, 32(11), 1495-1519.
- Kampourakis, K. (2017). Nature of science representations in Greek secondary school biology textbooks. In C. V. McDonald & F. Abd-El-Khalick (Eds.), *Representations of nature of science in school science textbooks* (pp. 118-134). New York: Routledge.
- Karabas, N. (2017). *The effect of scientific practice-based instruction on seventh graders' perceptions of scientific practices* (Publication No. 480247) [Master thesis, Bogazici University]. Ulusal Tez Merkezi.
- 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.

- Kaya, S., Erduran, S., Birdthistle, N., & McCormack, O. (2018). Looking at the social aspects of nature of science in science education through a new lens: The role of economics and entrepreneurship. *Science & Education*, 27(5–6), 457–478.
- 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(9-10), 1115-1133.
- Kelly, R., & Erduran, S. (2019). Understanding aims and values of science: developments in the junior cycle specifications on nature of science and pre-service science teachers' views in Ireland. *Irish Educational Studies*, 38(1), 43-70.
- Kesidou, S., & Roseman, J. E. (2002). How well do middle school science programs measure up? Findings from Project 2061's curriculum review. *Journal of Research in Science Teaching*, 39(6), 522–549.
- Khishfe, R., & Abd-El-Khalick, F. (2002). Influence of explicit and reflective versus implicit inquiry-oriented instruction on sixth graders' views of nature of science. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, 39(7), 551-578.
- Khishfe, R. (2008). The development of seventh graders' views of nature of science. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, 45(4), 470-496.
- King, C. J. H. (2010). An analysis of misconceptions in science textbooks: Earth science in England and Wales. *International Journal of Science Education*, 32(5), 565-601.
- Kitcher, P. (2011). *Science in a democratic society*. New York: Prometheus Books.
- Klopfer, L. E., & Watson, F. G. (1957). Historical materials and high school science teaching. *The Science Teacher*, 24(6), 264-293.

- Knorr-Cetina, K. (1999). *Epistemic cultures: How the sciences make knowledge*. Cambridge, MA: Harvard University Press.
- Kook, D. S. (2003). An analysis of 10th grade science textbook as an origin of misconception on greenhouse effect concept. *Journal of the Korean Association for Science Education*, 23(5), 592-598.
- Krippendorff, K. (1980). *Content analysis: An introduction to its methodology*. Beverly Hills, CA: Sage.
- Krippendorff, K. (2004). *Content analysis: An introduction to its methodology* (2nd ed.). Thousand Oaks, CA: Sage.
- Kuhn, T. S. (1977). *The essential tension*. Chicago: University of Chicago Press.
- Kuhn, T. (1970). *The structure of scientific revolutions* (2nd ed.). Chicago: University of Chicago Press.
- Kyngäs, H., & Vanhanen, L. (1999) Content analysis (Finnish). *Hoi-totiede* 11, 3-12.
- LaFollette, H., & Shanks, N. (1996). *Brute science*, New York: Routledge.
- Lakoff, S. (1980). Ethical responsibility and the scientific vocation. In S. Lakoff (Eds.) *Science and ethical responsibility* (pp.19-32). Addison-Wesley Reading, MA. 19-32.
- Laudan, L. (1984). *Science and values: The aims of science and their role in scientific debate*. Univ of California Press.
- Laws, K., Horsley, M., Young, C., & Downey, M. (1990). *Textbook availability and usage in NSW Non-government secondary schools, a report of the textbooks in NSW Secondary schools project*. Sydney: School of Teaching and Curriculum Studies, The University of Sydney.

- Leden, L., & Hansson, L. (2019). Nature of science progression in school year 1–9: a case study of teachers' suggestions and rationales. *Research in Science Education*, 49(2), 591-611.
- Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of nature of science questionnaire (VNOS): Toward valid and meaningful assessment of learners conceptions of nature of science. *Journal of Research in Science Teaching*, 39(6), 497–521.
- Lederman, N. G., Antink, A., & Bartos, S. (2014). Nature of science, scientific inquiry, and socio-scientific issues arising from genetics: A pathway to developing a scientifically literate citizenry. *Science & Education*, 23(2), 285-302.
- Lederman, J. S., & Lederman, N. G. (2004, April). Early elementary students' and teacher's understandings of nature of science and scientific inquiry: Lessons learned from Project ICAN. In: *Meeting of the National Association for Research in Science Teaching*, Vancouver, British Columbia.
- Lederman, J. S., Lederman, N. G., Kim, B. S., & Ko, E. K. (2012). Teaching and learning of nature of science and scientific inquiry: Building capacity through systematic research-based professional development. In *Advances in nature of science research* (pp. 125-152). Dordrecht: Springer.
- Lederman, N. G., & Lederman, J. S. (2012). Nature of scientific knowledge and scientific inquiry: Building instructional capacity through professional development. In *Second international handbook of science education* (pp. 335-359). Dordrecht: Springer.
- Lederman, N. G. (2013). Nature of science: Past, present, and future. In *Handbook of research on science education* (pp. 845-894). Routledge.

- Lederman, N. G., & O'Malley, M. (1990). Students' perceptions of tentativeness in science: Development, use, and sources of change. *Science Education*, 74(2), 225 – 239.
- 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. (1999). Teachers' understanding of the nature of science and classroom practice: Factors that facilitate or impede the relationship. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, 36(8), 916-929.
- Lee, Y. H. (2014). Comparative analysis of the presentation of the nature of science in US high school biology and Korea high school science textbooks. *National Teacher Education Journal*, 7(2), 11-19.
- Lin, H. S., & Chiu, H. L. (2004). Student understanding of the nature of science and their problem-solving strategies. *International Journal of Science Education*, 26(1), 101-112.
- Li, X., Tan, Z., Shen, J., Hu, W., Chen, Y., & Wang, J. (2018). Analysis of five junior high school physics textbooks used in China for representations of nature of science. *Research in Science Education*, 50(3), 833-844
- Longino, H. (1997). Feminist epistemology as a local epistemology. *Aristotelian Society Supplementary Volume*, 71(1), 19–36.
- Longino, H. E. (1995). Gender, politics, and the theoretical virtues. *Synthese*, 104(3), 383-397.
- Lumpe, A.T., & Beck, J. (1996). A profile of high school biology textbooks using scientific literacy recommendations. *The American Biology Teacher*, 58(3), 147–153.

- Martínez-Gracia, M. V., Gil-Quílez, M. J., & Osada, J. (2006). Analysis of molecular genetics content in Spanish secondary school textbooks. *Journal of Biological Education*, 40(2), 35–60.
- 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). Dordrecht, The Netherlands: Springer.
- Merriam-Webster (n.d). Scientific method. In *Merriam-Webster.com dictionary*. Retrieved from <https://www.merriamwebster.com/dictionary/scientific%20method>, July 9, 2020.
- McComas, W. F. (2003). A textbook case of the nature of science: Laws and theories in the science of biology. *International Journal of Science and Mathematics Education*, 1(2), 141-155.
- McComas, W. F. (Ed.) (1998). *The nature of science in science education: Rationales and strategies*. Dordrecht, Netherlands: Kluwer (Springer) Academic Publishers.
- McComas, W. F. (Ed.). (2006). *The nature of science in science education: Rationales and strategies* (Vol. 5). Springer Science & Business Media.
- McComas, W. F., Clough, M. P., & Almazroa, H. (1998). The role and character of the nature of science in science education. In *The nature of science in science education* (pp. 3-39). Dordrecht: Springer.
- 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). Dordrecht: Kluwer.
- McDonald, C. V. (2017). Exploring representations of nature of science in Australian junior secondary school science textbooks: A case study of genetics. In C. V.

- McDonald & F. Abd-El-Khalick (Eds.), *Representations of nature of science in school science textbooks* (pp. 98-117). New York: Routledge.
- McDonald, C. V. (2016). Evaluating junior secondary science textbook usage in Australian schools. *Research in Science Education*, 46(4), 481-509.
- Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: A sourcebook of new methods* (2nd ed.). Thousand Oaks, CA: Sage.
- Milli Eğitim Bakanlığı (MEB). (2018). *İlköğretim kurumları fen bilimleri dersi öğretim programı*. Ankara: Talim ve Terbiye Kurulu Başkanlığı.
- Morrison, J. A., Raab, F., & Ingram, D. (2009). Factors influencing elementary and secondary teachers' views on the nature of science. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, 46(4), 384-403.
- Myers, M. (2000). Qualitative research and the generalizability question: Standing firm with Proteus. *The Qualitative Report*, 4(3).
- National Research Council (NRC). (2012). *A framework for k-12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: The National Academy Press.
- National Research Council (NRC). (1996). *National science education standards*. Washington, DC: The National Academy Press.
- Nersessian, N. (2003). Abstraction via generic modeling in concept formation in science. *Mind and Society*, 3(1), 129–154.
- Niaz, M. (2017). *Evolving nature of objectivity in the history of science and its implications for science education* (Vol. 46). Springer.

- Niaz, M., & Maza, A. (2011). Nature of science in general chemistry textbooks. In *Nature of science in general chemistry textbooks* (pp. 1-37). Dordrecht: Springer.
- Osborne, J., Collins, S., Ratcliffe, M., Millar, R., & Duschl, R. (2003). What “ideas- about- science” should be taught in school science? A Delphi study of the expert community. *Journal of Research in Science Teaching*, 40(7), 692– 720.
- Osborne, J. (2014). Scientific practices and inquiry in the science classroom. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education* (Vol. 2, pp. 579–599). New York, NY: Routledge.
- Overman, M., Vermunt, J. D., Meijer, P. C., Bulte, A. M.W., & Brekelmans, M. (2013). Textbook questions in context-based and traditional chemistry curricula analyzed from a content perspective and a learning activities perspective. *International Journal of Science Education*, 35(17), 2954–2978.
- Özden, M., & Cavlazoğlu, B. (2015). İlköğretim fen dersi öğretim programlarında bilimin doğası: 2005 ve 2013 programlarının incelenmesi. *Eğitimde Nitel Araştırmalar Dergisi*, 3(2), 40-65.
- Park, W., Wu, J.Y., & Erduran, S. (2019). Investigating the epistemic nature of STEM: Analysis of curriculum documents using the Family Resemblance Approach. In, J. Anderson & Y. Li (Eds.), *Integrated approaches to STEM education: An international perspective*. Dordrecht: Springer.
- Park, W., Yang, S., & Song, J. (2020). Eliciting students’ understanding of nature of science with text-based tasks: Insights from new Korean high school textbooks. *International Journal of Science Education*, 42(3), 426-450.
- Peacock, A., & Cleghorn, A. (2006). What do we believe are the issues with text-based and other learning materials? Are we caught in the web or lost in the textbook. In E. Bruillard, B. Asmotsbakken, S.V. Knudsen & M. Horsley (Eds.), *Caught in the*

web or lost in the textbook. Eighth International Conference on Learning and Educational Media.

Phillips, L. M., Norris, S. P., & Macnab, J. S. (2010). *Visualization in mathematics, reading and science education* (Vol. 5). Springer Science & Business Media.

Phillips, M. C., Vowell, J. E., Lee, Y. H., & Plankis, B. J. (2015). How do elementary science textbooks present the nature of science?. *The Educational Forum*, 79(2), 148-162.

Pizzini, E. L. (1992). The questioning level of select middle school textbooks. *School Science and Mathematics*, 92(2), 74-79.

Popper, K. R. (1963). *Conjectures and refutations*. London: Routledge and Kegan Paul.

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.

Reiser, B. J., Berland, L. K., & Kenyon, L. (2012). Engaging students in the scientific practices of explanation and argumentation. *The Science Teacher*, 79(4), 34.

Resnik, D. B. (2005). *The ethics of science: An introduction*. New York: Routledge.

Romberg, T. A., Carpenter, T. P., & Dremock, F. (Eds.). (2005). *Understanding mathematics and science matters*. Routledge.

Roseman, J. E., Stern, L., & Koppal, M. (2010). A method for analyzing the coherence of high school biology textbooks. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, 47(1), 47-70.

- Rudge, D. W., & Howe, E. M. (2009). An explicit and reflective approach to the use of history to promote understanding of the nature of science. *Science & Education*, 18(5), 561–580.
- Ryan, A. G., & Aikenhead, G. S. (1992). Students' preconceptions about the epistemology of science. *Science Education*, 76(6), 559–580.
- Ryder, J., Leach, J., & Driver, R. (1999). Undergraduate science students' images of science. *Journal of Research in Science Teaching*, 36(2), 201–220.
- Saribas, D. & Ceyhan, G. D. (2015). Learning to teach scientific practices: Pedagogical decisions and reflections during a course for pre-service science teachers. *International Journal of STEM Education*, 2(1), (1-13).
- Schwartz, R. S., Lederman, N. G., & Crawford, B. A. (2004). Developing views of nature of science in an authentic context: An explicit approach to bridging the gap between nature of science and scientific inquiry. *Science Education*, 88(4), 610-645.
- Senler, B. (2015). Middle school students' views of scientific inquiry: An international comparative study. *Science Education International*, 26(2), 166-179.
- Shepardson, D. P., & Pizzini, E. L. (1991). Questioning levels of junior high school science textbooks and their implications for learning textual information. *Science Education*, 75(6), 673-682.
- Shrader-Frechette, K. S. (1994). *Ethics of scientific research*. Rowman & Littlefield.
- Smith, M. U., Lederman, N. G., Bell, R. L., McComas, W. F., & Clough, M. P. (1997). How great is the disagreement about the nature of science: A response to Alters. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, 34(10), 1101-1103.

- Smith, M. U., & Scharmann, L. C. (1999). Defining versus describing the nature of science: A pragmatic analysis for classroom teachers and science educators. *Science Education*, 83(4), 493-509.
- Spiegel Jr, G.F., & Barufaldi, J.P. (1994). The effects of a combination of text structure awareness and graphic post organizers on recall and retention of science knowledge. *Journal of Research in Science Teaching*, 31(9), 913-932.
- Stake, R.E. & Easley, J.A. (1978). *Case studies in science education*. Center for Instructional Research and Curriculum Evaluation, University of Illinois at Urbana Champaign.
- Stern, L., & Roseman, J. (2004). Can middle school science textbooks help students learn important ideas? Findings from Project 2061' curriculum evaluation study: Life science. *Journal of Research in Science Teaching*, 41(6), 538–568.
- Stone, P. J., Dunphy, D. C., & Smith, M. S. (1966). *The general inquirer: A computer approach to content analysis*. M.I.T. Press.
- Sülükçü, Y., (2018). Ders kitapları incelemesinde karşılaşılan problemler ve incelemenin iyileştirilmesi hususunda bazı öneriler. *Ders Kitapları Uluslararası Sempozyumu (DEKUS)*. İstanbul, Türkiye
- Şahin, Ş., & Köseoğlu, F. (2016). Bilimin doğasına ilişkin kazanımlar açısından Türkiye'deki lise kimya ders kitapları. *Cumhuriyet Uluslararası Eğitim Dergisi*, 5(4), 103-125.
- Talim ve Terbiye Kurulu Başkanlığı [TTKB]. (2019). *Ders kitapları hakkında merak edilenler*.http://ttkb.meb.gov.tr/meb_iys_dosyalar/2019_08/26180800_ders_kitapları_hakkında_brsr.pdf

- Tuan, H. L., & Chin, C. C. (1999, March). "What can inservice Taiwanese science teachers learn and teach about the nature of science?" In: *Meeting of the National Association for Research in Science Teaching*, Boston, MA.
- Ulerick, S. L. (1989). Using textbooks for meaningful learning in science. *National Association for Research in Science Teaching: Research Matters to the Science Teacher*.
- van Frassen, B. (1980). *The scientific image*. Oxford, UK: Clarendon.
- Walford, G. (1980). The masculine face of science. *Education 3-13*, 8(1): 51-53.
- Weber, R. P. (1990). *Basic content analysis*. Beverly Hills, CA: Sage.
- Wei, B., Li, Y., & Chen, B. (2013). Representations of nature of science in selected histories of science in the integrated science textbooks in China. *School Science and Mathematics*, 113(4), 170-179.
- Weis, A. M. (2013). *2012 National survey of science and mathematics education: Status of middle school science*. Chapel Hill, NC: Horizon Research.
- Weiss, I. R., Nelson, B. H., Boyd, S. E., & Hudson, S. B. (1989). *Science and mathematics education briefing book*. Chapel Hill, NC: Horizon Research.
- Wilkinson, J. (1999). A quantitative analysis of physics textbooks for scientific literacy themes. *Research in Science Education*, 29(3), 385-399.
- Williams, J. (2003). Ideas and evidence in science: The portrayal of scientists in GCSE textbooks. *School Science Review*, 84(309), 89-101.
- Wittgenstein, L. (1958). *Philosophical investigations*. Blackwell: Oxford.

- Woodcock, B. A. (2014). The scientific method as myth and ideal. *Science & Education*, 23(10), 2069-2093.
- Woodcock, B. A. (2013, June). The scientific method on trial. In: *International History and Philosophy in Science Teaching Biennial Meeting*, Pittsburgh, PA.
- Valverde, G. A., Bianchi, L. J., Wolfe, R. G., Schmidt, W. H., & Houang, R. T. (2002). *According to the book: Using TIMSS to investigate the translation of policy into practice through the world of textbooks*. Dordrecht: Kluwer.
- Vasconcelos, C., Torres, J., Dourado, L. G. P., & Leite, L. (2012). Questions in science textbooks: Do they prompt students' inquiry and problem-based learning?. In: *Annual Meeting of European Science Education Research Association (ESERA)*.
- Vesterinen, V. M., Aksela, M., & Lavonen, J. (2013). Quantitative analysis of representations of nature of science in Nordic upper secondary school textbooks using framework of analysis based on philosophy of chemistry. *Science & Education*, 22(7), 1839-1855.
- Yacoubian, H. (2012). *Towards a philosophically and a pedagogically reasonable nature of science curriculum* [Unpublished doctoral dissertation]. University of Alberta, Edmonton, Canada.
- Yamak, Y. (2009). *Exploring representation of nature of science aspects in science textbooks* (Publication No. 250711) [Master thesis, Middle East Technical University]. Ulusal Tez Merkezi.
- 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. *Science & Education*, 28(3-5), 291-310.

- Zajkov, O., Gegovska-Zajkova, S., & Mitrevski, B. (2017). Textbook-caused misconceptions, inconsistencies, and experimental safety risks of a grade 8 physics textbook. *International Journal of Science and Mathematics Education*, 15(5), 837-852.
- Ziman, J. M. (1987). *An introduction to science studies: The philosophical and social aspects of science and technology*. Cambridge: Cambridge University Press.

APPENDIX A: INTERVIEW QUESTIONS FOR SCIENCE TEACHERS (ENGLISH)

Teacher Interview Questions

Questions for NOS

1. What is your branch? For how long have you been teaching?
2. What is science? How do you define science?
3. What comes to your mind when I say nature of science (NOS)?
4. What do aims and values of science mean to you? Can you give examples of aims and values of science? (AV)
5. What are the scientific methods? Can you give examples of scientific methods? (M)
 - Is there one scientific method that is followed by all scientists? Why?
 - Do all branches of science use the same scientific method? Does this differ? How?
6. What do scientific practices mean to you? Can you give examples of scientific practices? (SP)
7. What is the scientific knowledge? (SK)
 - Do you think scientific knowledge can change? Please explain.
8. What do social and institutional aspects of science mean to you? Can you give any examples?
 - What do you think about the social certification and dissemination? I mean, in what ways can scientists share their work with others? (SCD)
 - What does the scientific ethos mean to you? So, are there any norms that scientists follow when interacting with colleagues or during their own work? What are they? (SE)
 - What do you think of social values of science? What can be the social values of science? (SV)
 - What professional activities do scientists do? (PA)
 - What comes to your mind when I say social organizations and interactions? Where is scientific knowledge produced? (SOI)

- What do you think about the relationship between science and financial systems? Do scientists need money for their research? (FS)
- Is there a relationship between science and political power structure? Do you think science is affected by political power structures? (PPS)

Questions for science textbooks

9. Do you make use of science textbooks when planning and performing science lessons? How?
10. Do you use alternative science books in your classes? Why?
11. Is it important to teach NOS to students? Why?
12. Do you integrate NOS in your lessons? Why? How?
13. Do you use the textbook in the teaching of nature of science? How?
14. Which grade science textbooks and topics give more emphasis on NOS? Why?

Questions for teachers' suggestions

15. How should RFN categories be included in textbooks?
 - Are statements about the aims and values of science found in science textbooks? How can it be included? (AV)
 - Are statements related to scientific methods found in science textbooks? How can it be included? (M)
 - Are statements related to scientific practices found in science textbooks? How can it be included? (SP)
 - Are statements related to scientific knowledge included in science textbooks? How can it be included? (SK)
 - Are statements related to the social certification and dissemination found in science textbooks? How can it be included? (SCD)
 - Are statements related to the scientific ethos found in science textbooks? How can it be included? (SE)
 - Are statements about the social values of science found in science textbooks? How can it be included? (SV)
 - Are statements about professional activities participated by scientists included in science textbooks? How can it be included? (PA)

- Are statements about social institutions and their interactions found in science textbooks? How can it be included? (SOI)
- Are statements related to the relationship between science and financial systems found in science textbooks? How can it be included? (FS)
- Are statements about the effect of political power structures on scientific knowledge included in science textbooks? How can it be included? (PPS)

16. How should teachers use the nature of science included in science textbooks during their course planning and adaptation process?

APPENDIX B: INTERVIEW QUESTIONS FOR SCIENCE TEACHERS (TURKISH)

Öğretmen Görüşme Soruları

Bilimin doğasına yönelik sorular

1. Branşınız nedir? Ne zamandır öğretmenlik yapıyorsunuz?
2. Sizce bilim nedir? Bilimi nasıl tanımlarsınız?
3. Bilimin doğası dediğim zaman aklınıza ne geliyor?
4. Bilimin amaçları ve değerleri sizin için ne ifade ediyor? Bilimin amaç ve değerlerine örnekler verebilir misiniz? (AV)
5. Bilimsel yöntemler nelerdir? Bilimsel yöntemlere örnekler verebilir misiniz? (M)
 - Tüm bilim insanları tarafından takip edilen tek bir bilimsel yöntem mi vardır? Neden?
 - Bütün bilim dalları aynı bilimsel yöntemi mi kullanır? Bu farklılaşır mı? Nasıl?
6. Bilimsel pratikler sizin için ne ifade ediyor? Bilimsel pratiklere örnekler verebilir misiniz? (SP)
7. Bilimsel bilgi nedir? (SK)
 - Bilimsel bilginin değişebileceğini düşünüyor musunuz? Lütfen açıklayınız.
8. Bilimin sosyal ve kurumsal yönleri var mıdır? Örnek verebilir misiniz?
 - Sosyal kabul ve dağılım süreci hakkında ne düşünüyorsunuz? Demek istediğim, bilim insanları çalışmalarını başkalarıyla hangi yollarla paylaşabilir? (SCD)
 - Bilimsel değerler sistemi size neyi ifade ediyor? Yani, bilim insanlarının meslektaşları ile etkileşimi sırasında ya da kendi çalışmaları sırasında takip ettikleri normlar var mıdır? Varsa nelerdir? (SE)
 - Bilimin sosyal değerleri denilince aklınıza ne geliyor? Bilimin sosyal değerleri neler olabilir? (SV)
 - Bilim insanları ne tür profesyonel etkinlikler yaparlar? (PA)
 - Sosyal kurumlar ve etkileşimler denilince aklınıza ne geliyor? Bilimsel bilgi nerelerde üretilir? (SOI)
 - Bilim ve finansal sistemler arasındaki ilişki hakkında ne düşünüyorsunuz? Bilim insanları araştırmaları için paraya ihtiyaç duyarlar mı? (FS)

- Bilim ve politik güç yapısı arasında bir ilişki var mıdır? Sizce bilim politik güç yapılarından etkilenir mi? (PPS)

Fen ders kitaplarına yönelik sorular

9. Fen derslerini planlarken ve gerçekleştirirken fen ders kitaplarından yararlanıyor musunuz? Nasıl?
10. Sınıflarınızda alternatif fen kitapları kullanıyor musunuz? Neden?
11. Öğrencilere bilimin doğasını öğretmek önemli midir? Neden?
12. Fen derslerinizde NOS u öğretiyor musunuz? Nasıl?
13. Ders kitabını bilimin doğasını öğretmek için kullanıyor musunuz? Nasıl?
14. Kaçınıcı sınıfların fen ders kitapları ve konularının bilimin doğasına daha çok vurgu yaptığını düşünüyorsunuz? Neden?

Öğretmenlerin önerilerine yönelik sorular

15. RFN kategorileri ders kitaplarına nasıl dâhil edilmeli?
 - Bilimin amaç ve değerlerine ilişkin ifadeler fen ders kitaplarında bulunuyor mu? Nasıl dâhil edilebilir? (AV)
 - Bilimsel yöntemlere ilişkin ifadeler fen ders kitaplarında bulunuyor mu? Nasıl dâhil edilebilir? (M)
 - Bilimsel pratiklere ilişkin ifadeler fen ders kitaplarında bulunuyor mu? Nasıl dâhil edilebilir? (SP)
 - Bilimsel bilgiye ilişkin ifadeler fen ders kitaplarında bulunuyor mu? Nasıl dâhil edilebilir? (SK)
 - Sosyal kabul ve dağılım sürecine ilişkin ifadeler fen ders kitaplarında bulunuyor mu? Nasıl dâhil edilebilir? (SCD)
 - Bilimsel değerler sistemine ilişkin ifadeler fen ders kitaplarında bulunuyor mu? Nasıl dâhil edilebilir? (SE)
 - Bilimin sosyal değerlerine ilişkin ifadeler fen ders kitaplarında bulunuyor mu? Nasıl dâhil edilebilir? (SV)
 - Bilim insanların yaptığı profesyonel etkinliklere ilişkin ifadeler fen ders kitaplarında bulunuyor mu? Nasıl dâhil edilebilir? (PA)
 - Sosyal kurumlar ve etkileşimlere ilişkin ifadeler fen ders kitaplarında bulunuyor mu? Nasıl dâhil edilebilir? (SOI)

- Bilimin finansal sistemlerle ilişkisine ilişkin ifadeler fen ders kitaplarında bulunuyor mu? Nasıl dâhil edilebilir? (FS)
- Politik güç yapılarının bilimsel bilgi üzerindeki etkisine ilişkin ifadeler fen ders kitaplarında bulunuyor mu? Nasıl dâhil edilebilir? (PPS)

16. Öğretmenler fen kitaplarına dâhil edilen bilimin doğası içeriklerini dersi planlama ve gerçekleştirme sürecince nasıl kullanmalılar?

APPENDIX C: NATURE OF SCIENCE QUESTIONNAIRE

BİLİMİN DOĞASI ANKETİ

BÖLÜM 1: DEMOGRAFİK BİLGİLER

İsim ve Soyisim İlk İki Harf :

(Görüşme verileriyle eşleştirmek için sorulmaktadır)

Cinsiyet :

Öğretmenlik deneyiminiz (yıl olarak):

Okul Türü:

- ☐ Devlet Okulu
- ☐ Özel Okul

BÖLÜM 2: BİLİMİN DOĞASI ANKETİ

Yönerge: Bu ankette bilimin doğası hakkında 70 madde bulunmaktadır. Lütfen bu maddeleri dikkatlice okuyun ve maddelere ilişkin fikrinizi en iyi tanımlayan seçeneği seçin. Anketteki seçenekler “Kesinlikle Katılmıyorum”, “Katılmıyorum”, “Kararsızım”, “Katılıyorum” ve “Kesinlikle Katılıyorum” şeklindedir.

	Kesinlikle Katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
1. Fen dersleri bilimin finansal (ekonomik) yönünü içermelidir.					
2. Bilimin epistemik (bilgisel), bilişsel ve sosyal yönleri birbirinden çok belirgin bir şekilde ayrılmaz.					
3. Bilimsel bilgi değişmez.					
4. Bilim insanları birbirlerinin çalışmalarını inceler ve değerlendirir.					
5. Deneyin güçlü olmasının sebebi bir bilimsel hipotezin bilim insanları tarafından birçok defa test edilmesidir					

	Kesinlikle Katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
6. Kavram haritaları, bilimsel pratiklerden sınıflandırmanın öğretilmesi için etkili bir yöntem olabilir.					
7. Bilim, üniversiteler ve araştırma merkezleri gibi kurumlarda gerçekleşir.					
8. Fizik, kimya ve biyoloji gibi bütün bilimsel disiplinler aynı bilimsel yöntemi kullanır.					
9. Bilim sosyal bir sistemdir.					
10. Bilimsel ilerleme fikirlerin değerlendirilmesi ve gözden geçirilmesiyle gerçekleşir.					
11. Bilimin her branşı farklı bir doğaya sahiptir.					
12. Öğrenciler deney yaparken kullanacakları yöntemleri kendileri belirlemelidir.					
13. Politika bilimi etkilemez.					
14. Bilim insanları çevreye saygı göstermelidir.					
15. Verilerin analizi ve yorumlanması, bilimsel pratiklerin bileşenlerindendir.					
16. Teoriler ve yasalar bilimsel bilgi türleridir; ancak modeller bilimsel bilgi türü değildir.					
17. Fen derslerinde bilimin amaç ve değerlerini öğretmek, öğrencilerin bilişsel beceri seviyesini artırır.					
18. Bilim insanları araştırmalarını toplumla paylaşmak zorunda değillerdir.					
19. Bilim insanları kompleks bilimsel fikirleri anlayabilmek için modeller oluşturup kullanırlar.					
20. Bir problemin farklı bilim insanları tarafından çözülmesi, sonuçların daha az önyargılı olduğu anlamına gelir.					
21. Öğrenciler teorilerin, modellerin birleştirilmiş hali olduğunu anlamalıdır.					
22. Bilim yaparken adım adım takip edilecek bir sıralama yoktur.					
23. Gözlem tüm bilim dallarında kullanılır.					

	Kesinlikle Katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
24.Yöntemlerin çeşitliliği bilimsel anlayışı artırır.					
25.Bütün hipotez testleri manipülatiftir.					
26.Bilimin bazı dallarında simgeler (örneğin şekil, sembol ya da resim) kullanılmaz.					
27.Öğrencileri bilimin amaç ve değerleri hakkında eğitmek bilimsel okur yazarlığı geliştirir.					
28.Bilim insanları, problemleri çözebilecek yeterli kanıt üretebilmek için farklı yöntemler kullanmak zorundadırlar.					
29.Bilim insanları araştırma yaparken diğer bilim insanlarıyla işbirliği yaptıkları için öğrenciler de fen derslerinde akranlarıyla işbirliği yapmaları için teşvik edilmelidir.					
30.Bilimsel bilgi birbiriyle uyumlu olan fikirler dizisinden oluşur.					
31.Müfredat, kimya ve fizikteki teorilerin aynı olduğunu vurgulamalıdır.					
32.Bilim insanları araştırma yapmak için paraya ihtiyaç duyarlar.					
33.Sınıflandırma bilim insanlarının olayları açıklamasına ve tahmin etmesine yardımcı olur.					
34.Fizik, biyoloji ve kimya gibi tüm bilimsel disiplinler topluma katkıda bulunabilecek değerler üretir.					
35.Öğrencilerin deneysel verilerle ilgili tartışmalara katılmaları onların bilimi öğrenmelerini etkilemez.					
36.Bilim insanlarının cinsiyetleri onların bilimi nasıl yaptıklarını etkiler.					
37.Bilim insanlarının dünyanın her yerinde kullandığı evrensel bir bilimsel yöntem vardır.					
38.Bilimsel deneyler yapılırken belli başlı prosedürler takip edilir.					

	Kesinlikle Katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
39.Bilimdeki entelektüel dürüstlük kavramının derslerde öğrencilere öğretilmesi zorunlu değildir.					
40.Bilim insanları düşüncelerinin kanıtlarla desteklenmediğini fark ettiklerinde fikirlerini değiştirmelidir.					
41.Hükümetlerin politikaları bilimsel bilginin gelişimini etkiler.					
42.Öğrenciler bazen araştırmalarında kullanacakları yöntemleri belirleme hakkına sahip olmalıdır.					
43.Yasalar doğrulanmış teorilerdir.					
44.Bilimsel modeller, gerçek dünyayı temsil eden araçlardır.					
45.Bazı bilim insanlarının diğerlerinden daha fazla para kazanması bilim insanları arasında gerginliğe yol açar.					
46.Bilimsel gerçekler, bilim insanlarının önyargılarından ve öznel düşüncelerinden etkilenmez.					
47.Bilim öğretiminde yasaların kesin ve değişmez olduğu belirtilmelidir.					
48.Bilim insanlarının ırklarının ve etnik kökenlerinin, bilimle hiçbir ilgisi yoktur.					
49.Değişkenleri değiştirmek bilimsel bir çalışma için temel koşuldur.					
50.Teoriler, yasalar ve modeller birlikte çalışarak bilimsel bilgi üretir					
51. Epistemik, bilişsel, sosyal ve kültürel değerleri öğretmek fen müfredatının temel bileşenleri olmalıdır.					
52.Fizik, biyoloji ve kimya gibi farklı bilim dalları aynı pratiklere sahiptirler.					
53.Bilim insanları akademik dergilerde makaleler yazarlar.					
54.Farklı türde teoriler vardır. Bazı teoriler kabul edilmiştir, bazıları ise hala tartışılmaktadır.					
55.Fen müfredatı sadece bilimsel bilgiyi değil, bilimin sosyal, kültürel ve epistemik yönlerini de kapsamalıdır.					

	Kesinlikle Katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
56. Bilimsel gerçekler ve değerler arasında hiçbir ilişki yoktur.					
57. Tüm bilim dallarında, bilim insanları birbirlerinin fikirlerini değerlendirerek bilimsel bilgiyi doğrularlar.					
58. Bilim insanları, araştırmalarını diğer bilim insanlarıyla paylaşmak için konferanslara katılırlar.					
59. Bilimsel yöntemleri anlamak öğrencilerin bilim ile bilim dışı arasındaki ayrımı yapmasına yardımcı olabilir.					
60. Fizik, biyoloji ve kimya gibi tüm bilim dallarında hipotez oluşturulması gerekir.					
61. Bilimsel çalışmanın kalitesini değerlendirmek için oluşturulmuş standartlar vardır.					
62. Bilimsel amaç ve değerlerin içselleştirilmesi öğrencilerin bilimsel bilgi ve konuları anlamalarına yardımcı olur.					
63. Modeller bilim insanlarının olayları açıklamalarına ve tahmin etmelerine yardımcı olur.					
64. Bilimsel pratikler bilginin üretilmesini sağlar ve kültürel faktörlerden etkilenmezler.					
65. Öğrenciler bilim insanlarının dürüstlük gibi sosyal değerlere sahip olmaları gerektiğini anlamalıdır.					
66. Yasalar teorilere göre daha doğrulanabilir bilimsel bilgilerdir.					
67. Bilim ekipleri arasında birtakım hiyerarşiler vardır ve bu hiyerarşiler değişebilir.					
68. Öğrencilerin bilimsel bilginin nasıl geliştiğini anlamaları gerekli değildir.					
69. Bilimsel amaç ve değerler, bilim insanlarının yöntem seçimini etkiler					
70. Bilim insanları araştırma yaparken diğer bilim insanlarıyla sosyal olarak etkileşimde bulunurlar.					

APPENDIX D: THE CONTENT OF THE 5TH-GRADE SCIENCE TEXTBOOK

Laboratory Safety Symbols		
Science and Engineering Applications		
1 st Unit: Sun, Earth, and Moon	1 st Section: Structure and Properties of the Sun	
	2 nd Section: Structure and Properties of the Moon	
	3 rd Section: Movements and Phases of the Moon	
	4 th Section: Sun, Earth, and Moon	
	Science and Engineering Designs	
	Let's Measure What We Learn	
2 nd Unit: The World of Living Things	1 st Section: Knowing of Living Things	Living Things
		Microscopic Creatures
		Fungi
		Plants
		Animals
	Science and Engineering Designs	
	Let's Measure What We Learn	
3 rd Unit: Measurement of Force and Friction	1 st Section: Measurement of Force	Force
	2 nd Section: Friction Force	Frictional Force Acting on the Object
	Science and Engineering Designs	
	Let's Measure What We Learn	
4 th Unit: Matter and Change	1 st Section: Change of State of Matter	Changes in Matter
	2 nd Section: Distinctive Features of Matter	
	3 rd Section: Heat and Temperature	What Are Heat and Temperature?

	4 th Section: Heat Affects Matter	How Does Heat Affect Matter?
	Science and Engineering Designs	
	Let's Measure What We Learn	
5 th Unit: Propagation of Light	1 st Section: Propagation of Light	How Does Light Spreads?
	2 nd Section: Reflection of Light	
	3 rd Section: Meeting of Light and Matter	What Happens When Light Meets Matter?
	4 th Section: Umbra	Formation of Umbra
	Science and Engineering Designs	
	Let's Measure What We Learn	
6 th Unit: Human and Environment	1 st Section: Biodiversity	
	2 nd Section: Human and Environment	
	3 rd Section: Natural Disasters Destructive	
	Science and Engineering Designs	
	Let's Measure What We Learn	
7 th Unit: Electrical Circuit Components	1 st Section: Representation of Circuit Elements with Symbols and Circuit Diagrams	Circuit Diagrams
	2 nd Section: Variables Affecting Bulb Brightness in a Simple Electric Circuit	How Does the Brightness of the Bulbs Change?
	Science and Engineering Designs	
	Let's Measure What We Learn	

APPENDIX E: THE CONTENT OF THE 6TH-GRADE SCIENCE TEXTBOOK

Science, Engineering and Entrepreneurship Applications		
Laboratory Security in Science Course		
1 st Unit: Solar System and Eclipses	1 st Section: Solar System	Planets in the Solar System
		Meteor, and Meteorite
		Asteroids
		What We Learned?
		Assessment of Subject 1
	2 nd Section: Sun and Moon Eclipse	Eclipse of Sun
		Eclipse of Moon
		What We Learned?
		Assessment of Subject 2
		Assessment of Unit 1
2 nd Unit: Systems in Our Body	1 st Section: Musculoskeletal System	Structures and Organs Constituting Support and Movement System
		Bones and Types of Bones
		Joints and Types of Joints
		Muscle and Types of Muscles
		What We Learned?
		Assessment of Subject 1
	2 nd Section: Digestive System	Digestive System Parts and Organs
		Physical and Chemical Digestive
		Organs That Help Digestion
		What We Learned?
		Assessment of Subject 2

	3 rd Section: Circulatory System	Circulatory System Parts and Organs
		Systemic and microcirculation
		Structure and Functions of Blood
		Blood Groups and Blood Exchange
		Blood Donation and Its Importance in Society
		What We Learned?
		Assessment of Subject 3
	4 th Section: Respiratory System	Respiratory System Parts and Organs
		What We Learned?
		Assessment of Subject 4
	5 th Section: Urinary System	Urinary System Parts and Organs
		What We Learned?
		Assessment of Subject 5
		Assessment of Unit 2
3 rd Unit: Force and Movement	1 st Section: Resultant Force	Properties of Force
		Resultant Force
		Balanced and Unbalanced Forces
		What We Learned?
		Assessment of Subject 1
	2 nd Section: Constant Speed Motion	What is Speed?
		Plot the Moved One
		What We Learned?
		Assessment of Subject 2
		Assessment of Unit 3
4 th Unit: Matter and Heat	1 st Section: Granular Structure of Matter	Granular Structure of Matter
		How Does State Change Affect Particles?

		What We Learned?
		Assessment of Subject 1
	2 nd Section: Density	Density
		Density of Irregularly Shaped Solids
		Density of Liquids
		Densities of the Solid and Liquid States of Water
		What We Learned?
	3 rd Section: Matter and Heat	Assessment of Subject 2
		Let's Classify Materials According to Their Thermal Conductivity
		What is Heat Insulation?
		Let's Produce Heat Insulation Material
		The Importance of Heat Insulation
		What We Learned?
		Assessment of Subject 3
	4 th Section: Fuels	Knowing of Fuels
		The Effects of Fuels on People and the Environment
		Caution for Poisoning
		What We Learned?
		Assessment of Subject 4
		Assessment of Unit 4
5 th Unit: Sound and Features	1 st Section: Propagation of Sound	Environments Where Sound Can Be Spread
	2 nd Section: Hearing of Sounds Differently in Different Environments	Sound Source is Different, Ambient Same
		Sound Source is the Same, Ambience is Different

		Assessment of Subject 1
	3 rd Section: Speed of Sound	The Speed of the Spread of the Sound
		Lightning and Thunder
		Is Sound a Type of Energy?
		What We Learned?
		Assessment of Subject 2
	4 th Section: Interaction of Sound with Matter	What Happens When Sound Meets Matter?
		Can We Prevent the Spreading of Sound?
		Sound Insulation Technologies
		What is Acoustic?
		What We Learned?
		Assessment of Subject 3
		Assessment of Unit 5
6 th Unit: Systems of Our Body and Health of Systems	1 st Section: Regulatory and Supervisory Systems	Nervous System
		Endocrine Glands
		Transition from Childhood to Puberty
		Health of Puberty
		Regular and Coordinated Operation of Supervisory and Regulatory Systems with Other Systems
		What We Learned?
		Assessment of Subject 1
	2 nd Section: Sense Organs	The Structure of Sense Organs
		The Relationship Between Smell and Taste Senses
		Technologies Used to Eliminate Defects In The Sensory Organs

7 th Unit: Transmission of Electricity		Heath of Sense Organs
		What We Learned?
		Assessment of Subject 2
	3 rd Section: Health of Systems	What to Do for The Health of The Systems
		The Importance of Organ Donation
		What We Learned?
		Assessment of Subject 3
		Assessment of Unit 6
	1 st Section: Conductive and Insulating Matter	Knowing of Conductive and Insulating Matter
		Where to Use?
		What We Learned?
		Assessment of Subject 1
	2 nd Section: Electrical Resistance and Related Factors	Let's Change the Brightness of the Light Bulb
		What is Resistance?
		The Bulb Also a Resistor
		What We Learned?
		Assessment of Subject 1
		Assessment of Unit 7

APPENDIX F: THE CONTENT OF THE 7TH-GRADE SCIENCE TEXTBOOK

Laboratory Safety Symbols		
Science, Engineering and Entrepreneurship Applications	Product Design	
1 st Unit: Solar System and Beyond	1 st Section: Space Research	Technology and Space Research
		Space Pollution
		What is Telescope?
	2 nd Section: Beyond the Solar System: Celestial Bodies	Stars
		Types of Stars
		Galaxy
		Universe
		End-of-Unit Evaluation Questions
2 nd Unit: Cells and Divisions	1 st Section: Cell	Cell and Parts of the Cell
		Structure of Cell from Past to Present
		Cell - Tissue - Organ - System – Organism Relationship
	2 nd Section: Mitosis	Mitosis and the Importance of Mitosis for Living Things
		Stages of Mitosis Division
	3 rd Section: Meiosis	Meiosis and the Importance of Meiosis for Living Things
		Differences Between Mitosis and Meiosis
		End-of-Unit Evaluation Questions

3 rd Unit: Force and Energy	1 st Section: Mass and Weight Relationship	What is Weight?
	2 nd Section: Force, Work, and Energy Relationship	What is Work?
		Energy
		Kinetic Energy
		Potential Energy
	3 rd Section: Conversions of Energy	Conservation of Energy
		Friction Force and Energy
		The Effect of Air and Water Resistance on Life
		End-of-Unit Evaluation Questions
4 th Unit: Pure Substances and Mixtures	1 st Section: Granular Structure of Matter	Structure of Matter
		Atom Concept from Past to Present
		What is Molecule?
	2 nd Section: Pure Substances	What is Pure Substance?
		Elements Compounds
	3 rd Section: Mixtures	Knowing of Mixtures

		Heterogeneous Mixtures
		Homogenous Mixtures
		How Does Dissolution Happen?
	4 th Section: Separation of Mixtures	Some Methods Used in the Separation of Mixtures
		Evaporation
		Distillation
		Separation by Density Difference
	5 th Section: Domestic Waste and Recycling	Recycling
		Ensuring Waste Control
		End-of-Unit Evaluation Questions
5 th Unit: Interaction of Light with Matter	1 st Section: Absorption of Light	How Does Absorption of Light Occur?
		How Is White Light Formed?
		How Do Objects Look Colorful?
		Sun Energy
	2 nd Section: Mirrors	Mirrors and Usage Areas of Mirrors
		Sheet Mirror
		Concave Mirror
		Convex Mirror
		What Are the Images Created on the Mirrors?
	3 rd Section: Refraction of Light and Lenses	How Does the Light Refract?
		Lenses
		Where Are Lenses Used?
		End-of-Unit Evaluation Questions
6 th Unit: Reproduction, Growth, and	1 st Section: Reproduction, Growth,	Structures and Organs Providing Reproduction in Human

Development in Living Things	and Development in Human	
		From Zygote to Baby
	2 nd Section: Reproduction, Growth, and Development in Plants and Animals	Reproduction Types in Plants and Animals Sexual Reproduction Asexual Reproduction
		Growth and Development of Plants and Animals
		The Factors Affecting the Growth and Development of Plants and Animals
7 th Unit: Electrical Circuits	1 st Section: Connection Types of Bulbs	End-of-Unit Evaluation Questions
		Connecting Bulbs in Series and Parallel
		Electrical Current
		End-of-Unit Evaluation Questions

APPENDIX G: THE CONTENT OF THE 8TH-GRADE SCIENCE TEXTBOOK

Safety Symbols		
1 st Unit: Seasons and Climate	1 st Section: Formation of Seasons	
	2 nd Section: Climate and Air Movements	Weather Events
		Meteorology
		The Effects of Weather Forecasts for Daily Life
		Climate
2 nd Unit: DNA and Genetic Code	1 st Section: DNA and Genetic Code	DNA Replication
	2 nd Section: Heritage	Concepts Related with Heredity
		Consanguineous Marriage
	3 rd Section: Mutation and Modification	Mutation
		Modification
		Differences Between Mutation and Modification
	4 th Section: Adaptation	Adaptation
		Natural Selection
	5 th Section: Biotechnology	Application Areas of Biotechnology
		Positive Effects of Biotechnology
		Negative Effects of Biotechnology
3 rd Unit: Pressure	1 st Section: Pressure	Solid Pressure
		Liquid Pressure
		Air Pressure

		Applications of Pressure in Daily Life and Technology
4 th Unit: Matter and Industry	1 st Section: Periodic System	
	2 nd Section: Physical and Chemical Changes	Physical Changes
		Chemical Changes
	3 rd Section: Chemical Reactions	
	4 th Section: Acid and Bases	General Properties of Acids and Bases
		Effects of Acids and Bases on Matter
		Acid Rains
	5 th Section: Interaction of Matter with Heat	
	6 th Section: Chemical Industry in Turkey	Development of Chemical Industry in Turkey
		Professionals in Chemical Industry and Organizations Contributing to the Chemical Industry
5 th Unit: Simple Machines	1 st Section: Simple Machines	Pulleys
		Levers
		Inclined Planes
		Gears
		Belt Pulleys
6 th Unit: Energy Conversions and Environmental Science	1 st Section: Food Chain and Flow of Energy	
	2 nd Section: Energy Conversion Systems	Photosynthesis
		Respiration
	3 rd Section: Cycles of Matter and Environmental Problems	Cycles of Matter
		Environmental Problems
		Ecological Footprint
	4 th Section: Sustainable Development	Recycling
		Saving of Uses of Resources
		Frictional Electricity

7 th Unit: Electrical Charges and Electrical Energy	1 st Section: Electrical Charges and Electricity	Electricity by Touching
		Electricity by Actions
		Grounding
	2 nd Section: Electrically Charged Objects 3 rd Section: Transformation of Electrical Energy	Conversion of Electrical Energy to Heat and Light Energy
		Conversion of Electrical Energy to Movement Energy
		How is Electrical Energy Produced?
		The Importance of Using Electrical Energy Consciously

APPENDIX H: SCIENCE TEXTBOOK CODING RUBRIC

Science Textbook Coding Rubric

Encoder Name:

Coding Date:

About the textbook:

Grade:

Unit name:

Page:

Units of analysis:

- Paragraphs
- Complete sentences
- Figures, diagrams and photos with captions
- Questions
- Steps of the activities

Directions:

1. The units are analyzed based on Reconceptualized Family Resemblance Approach to Nature of Science (RFN). The coding units given above are analyzed to examine representation of RFN in given pages.

2. While analyzing the coding units the descriptions of the RFN categories are considered. Analyzes is made in line with these categories and definitions (See Figure 1).

Figure 1. RFN categories and descriptions (Kaya & Erduran, 2016).

RFN category	Description
Aims and values	The key cognitive and epistemic objectives of science, such as accuracy and objectivity
Methods	The manipulative as well as non-manipulative techniques that underpin scientific investigations
Scientific practices	The set of epistemic and cognitive practices that lead to scientific knowledge through social certification
Scientific knowledge	Theories, laws, and explanations that underpin the outcomes of the scientific inquiry
Social certification and dissemination	The social mechanisms through which scientists review, evaluate, and validate scientific knowledge for instance through peer review systems of journals
Scientific ethos	The norms that scientists employ in their work as well as in interaction with colleagues
Social values	Values such as freedom, respect for the environment, and social utility
Professional activities	How scientists engage in professional settings such as attending conferences and doing publication reviews
Social organizations and interactions	How science is arranged in institutional settings such as universities and research institutes
Financial systems	The underlying financial dimensions of science including the funding mechanisms
Political power structures	The dynamics of power that exist between scientists and within science cultures

3. The keywords which were created by Kaya & Erduran (2016) are traced to examine RFN representation in given pages (See Figure 2). If the words in the textbook match the RFN category definition, they can be taken as code. If it does not match the definition of any of the RFN categories, it is not taken as a code.

Figure 2. RFN keywords (Kaya & Erduran, 2016).

RFN Category	Keywords
AV	Aim, value, goal, accuracy, objectivity
M	The method, scientific method, inquiry, process, hypothesis, manipulation of variables
SP	Observation, experimentation, data, explanation, model, argumentation, classification, prediction
SK	Knowledge, scientific knowledge, formulation of knowledge, theory, law, model
SCD	Peer-review, validate, evaluate, certification, dissemination, collaboration
SE	Scientific norms, ethics, bias, being skeptical, caution against bias
SV	Culture, cultural, social values, society, beliefs, freedom, respect
PA	Conference, article, presentation, writing, publishing, publication
SOI	University, research center, institution, organization
FS	Financial, funding, finance, economy, economical, budget
PPS	Political power, research team, team leader, team members, researcher, gender, ethnicity, race, nationality

Correct Code Example:

- *Observe the germination of the bean seed for several days. Based on your observations, explain the factors that influence the germination of bean seed.*

The coders should consider whether those keywords are in line with the descriptions of RFN categories. The keywords in first example can be put into **scientific practices category** which is the set of epistemic and cognitive practices that lead to scientific knowledge. The coder should write **observation** and **explanation** codes in the scientific practices category.

Incorrect Code Example:

- *Explain what would have happened if the Earth had not been orbited around the Sun.*

In this example, the **explanation** keyword is not in line with the scientific practice of RFN. It is just talking about something. Hence, the coders should not note it as a code in scientific practices category.

4. In addition to those keywords, the coders should trace textbook as a whole to generate new codes for each category

The new codes can be generated based on the meaning of the examined parts of the textbooks rather than tracing only one keyword such as **tentative** code for SK, **curing illnesses** for AV, **verification by trying** for SCD etc.

While analyzing the textbook and forming codes for each category the coders should consider whether the examined parts reflect the nature of science or not.

Sum of the Directions:

- 1) Trace the keywords given above (Kaya & Erduran, 2016) in each coding units OR generate new codes that are in line with RFN categories.
- 2) Note page number and example from textbook that belongs to code (Examples can be written in Turkish)

Note: The same code can be written more than once. The frequency of the codes is calculated by the researcher.

Analysis Matrix

RFN Category	Code	Page #	Example	Implicit / Explicit
AV				
SP				
M				
SK				
SCD				
SE				
SV				
PA				
SOI				
FS				
PPS				

* You can add new rows

APPENDIX I: INFORMED CONSENT FORM

Öğretmen Bilgi ve Onam Formu

Araştırmayı Destekleyen Kurum: Boğaziçi Üniversitesi

Araştırmanın Adı: Fen Bilimleri Ders Kitaplarının Bilimin Doğası Açısından İncelenmesi

Proje Yürütücüsünün Adı: Prof. Dr. Ebru Kaya

E-mail Adresi:

Telefonu:

Araştırmacının Adı: Beyza Okan

E-mail Adresi:

Telefonu:

Sayın öğretmen,

Boğaziçi Üniversitesi, Eğitim Fakültesi, Matematik ve Fen Eğitimi Alanlarında yüksek lisans yapmaktayım. Şu anda da 5, 6, 7 ve 8. sınıflarda kullanılan MEB fen bilgisi ders kitaplarının bilimin doğası açısından incelenmesi ve bu kitaplarla ilgili öğretmen görüşlerini içeren bir araştırma yapıyorum. Araştırmayı gerçekleştirmem için okul müdürünüz ve MEB tarafından gerekli izinler alındı. Siz de araştırmaya katılmayı kabul ederseniz bu araştırmaya katkı sağlayacaksınız. Çalışmaya katılıp katılmayacağınıza karar vermeden önce sizi çalışma hakkında bilgilendirmek istiyorum. Çalışmayla ilgili bilgileri okuduktan sonra bu araştırmaya katılmaya karar vererseniz lütfen bu formu imzalayıp bana teslim ediniz.

Çalışmayı kabul ettiğiniz takdirde bilimin doğası hakkında ve MEB tarafından verilen fen bilgisi ders kitaplarıyla ilgili görüşlerinizi almak açısından sizinle 20 ile 30 dk arasında sürecek görüşmeler gerçekleştireceğim. Bu görüşmeler esnasında sizin de izniniz doğrultusunda not almayı kolaylaştırmak için ses kaydı alınabilir. Bu araştırma bilimsel bir amaçla yapılmaktadır bu da katılımcı bilgilerinin gizliliğinin garanti altında olması anlamına gelir. Ses kaydı alınmasına izin verdiğiniz takdirde ses kayıtları araştırma sürecinde şifrelenmiş bir USB bellekte muhafaza edilip araştırma sona erdiğinde ise silinecektir. Görüşmelerimizden elde ettiğim veriler kimliğiniz gizli tutularak bilimsel yayın ve sunumlarda kullanılabilir. Çalışmada kimliğini gizli tutmak amacıyla size takma bir ad

atanacak ve çalışmanın her aşamasında bu takma ad ile kimlik bilgilerinizin gizliliği korunmuş olacaktır. Bu araştırmaya katılım tamamen gönüllülük esasına dayanmaktadır. Araştırmaya katılmayı kabul etseniz dahi çalışmanın herhangi bir anında hiçbir gerekçe göstermeksizin görüşmeyi sonlandırma hakkına sahipsiniz.

Bu çalışma hakkında ek bilgi almak isterseniz proje yürütücüsü olan Boğaziçi Üniversitesi Matematik ve Fen Bilimleri Eğitimi Bölümü Öğretim Üyesi Prof. Dr. Ebru Kaya ile iletişime geçebilirsiniz. (e-mail: ebru.kaya@boun.edu.tr). Araştırma ile ilgili haklarınız için Boğaziçi Üniversitesi Sosyal ve Beşeri Bilimler İnsan Araştırmaları Etik Kurulu (SBINAREK)'na başvurabilirsiniz. Eğer araştırmaya katılmayı kabul ediyorsanız lütfen aşağıda size ayrılan bölümleri doldurunuz.

Ben, ..., yukarıdaki metni okudum ve katılmam istenen çalışmanın kapsamını ve amacını, gönüllü olarak üzerime düşen sorumlulukları tamamen anladım. Çalışma hakkında kafamda herhangi bir soru işareti kalmadı. Görüşme sırasında istediğim zaman ve herhangi bir neden belirtmeden ayrılabileceğimi ve bu durumda herhangi bir olumsuzluk ile karşılaşmayacağımı anladım.

Bu koşullar doğrultusunda bu çalışmaya tamamen gönüllülük esasında hiçbir baskı ve zorlama olmadan katılmayı kabul ediyorum ve gereklilikleri konusunda üstüme düşen görevleri getireceğimi beyan ediyorum. Formun bir örneğini aldım / almak istemiyorum.

Öğretmen Adı-Soyadı:

İmzası:

Telefon:

E-mail:

Tarih (gün/ay/yıl):/...../.....

Araştırmacının Adı-Soyadı:

İmzası:

Tarih (gün/ay/yıl):/...../.....

APPENDIX J: PERMISSION FOR FIGURES

SPRINGER NATURE LICENSE TERMS AND CONDITIONS

May 10, 2021

This Agreement between Ms. Beyza Okan ("You") and Springer Nature ("Springer Nature") consists of your license details and the terms and conditions provided by Springer Nature and Copyright Clearance Center.

License Number	5065251415380
License date	May 10, 2021
Licensed Content Publisher	Springer Nature
Licensed Content Publication	Springer eBook
Licensed Content Title	Family Resemblance Approach to Characterizing Science
Licensed Content Author	Sibel Erduran, Zoubeida R. Dagher
Licensed Content Date	Jan 1, 2014
Type of Use	Thesis/Dissertation
Requestor type	non-commercial (non-profit)
Format	print and electronic
Portion	figures/tables/illustrations
Number of figures/tables/illustrations	5
Will you be translating?	no
Circulation/distribution	50000 or greater
Author of this Springer Nature content	no
Title	EXPLORING THE REPRESENTATION OF THE NATURE OF SCIENCE IN SCIENCE TEXTBOOKS
Institution name	Bogazici University
Expected presentation date	Jun 2021
Portions	Fig. 2.1 Fig. 3.1 Fig. 4.2 Fig. 5.4 Fig. 6.1
Requestor Location	

Attn: Ms. Beyza Okan

Total **0.00 USD**

Terms and Conditions

Springer Nature Customer Service Centre GmbH Terms and Conditions

This agreement sets out the terms and conditions of the licence (the **License**) between you and **Springer Nature Customer Service Centre GmbH** (the **Licensor**). By clicking 'accept' and completing the transaction for the material (**Licensed Material**), you also confirm your acceptance of these terms and conditions.