THE INCLUSION OF THE NATURE OF SCIENCE IN TURKISH SCIENCE CURRICULUM

by

Gözde Kurt

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Dedicated to my parents Güler and İbrahim Kurt

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ABSTRACT

THE INCLUSION OF THE NATURE OF SCIENCE IN TURKISH SCIENCE CURRICULUM

The Reconceptualized Family Resemblance Approach to Nature of Science (RFN) is a comprehensive approach that consists of the cognitive-epistemic and social-institutional systems of science (Erduran & Dagher, 2014a; Kaya & Erduran, 2016a). The purpose of the study is to examine the inclusion of the Nature of Science (NOS) in the Turkish science curriculum from the RFN perspective. Another purpose of the study is to investigate science teachers' views of the RFN and science curriculum. The Turkish science curriculum that was implemented in 2018 by the National Ministry of Education and used in the levels of primary school and middle school is the main data source of the study. The science curriculum was analyzed by content analysis. Furthermore, the participants of the study are 10 science teachers that were selected by purposive sampling. The semi-structured interview protocol and the RFN Questionnaire that was developed by Kaya *et al.* (2019) were applied to the science teachers. The data that comes from the interviews and the questionnaire were analyzed by thematic analysis and descriptive statistics, respectively. The findings of the study showed that the Turkish science curriculum refers more to the cognitive-epistemic system of science than the social-institutional system of science. The category of scientific practices has the highest code frequency, while the category of political power structures has the least code frequency in the science curriculum. Science teachers' RFN understanding levels were found moderate and high according to the RFN Questionnaire. However, in the interviews, it was realized that participants exhibit naïve views and limited knowledge about some RFN categories. The science teachers suggested that NOS should be integrated to the science curriculum more and sources about NOS should be increased. This study has implications for the inclusion of the RFN in the science curriculum and the integration of the RFN in the teacher-training.

ÖZET

TÜRKİYE'DEKİ FEN BİLİMLERİ DERSİ ÖĞRETİM PROGRAMINDAKİ BİLİMİN DOĞASI İÇERİĞİNİN İNCELENMESİ

Yeniden Kavramsallaştırılmış Aile Benzerliği Yaklaşımına Dayalı Bilimin Doğası (RFN), bilimin bilişsel-epistemik ve sosyal-kurumsal sistemlerinden oluşan kapsamlı bir yaklaşımdır (Erduran ve Dagher, 2014a; Kaya ve Erduran, 2016a). Bu çalışmanın amacı, bilimin doğasının Türkiye'deki fen bilimleri dersi öğretim programındaki içeriğini RFN bakış açısından incelemektir. Araştırmanın bir diğer amacı ise fen bilimleri öğretmenlerinin RFN ve fen bilimleri dersi öğretim programı hakkındaki görüşlerini incelemektir. Milli Eğitim Bakanlığı tarafından 2018 yılında uygulamaya konulan ve ilkokul ve ortaokul seviyelerinde kullanılan Türkiye'deki fen bilimleri dersi öğretim programı araştırmanın temel veri kaynağıdır. Fen bilimleri dersi öğretim programı içerik analizi ile analiz edilmiştir. Ayrıca, araştırmanın katılımcıları amaçlı örnekleme yoluyla seçilen 10 fen bilimleri öğretmenidir. Yarı yapılandırılmış görüşme protokolü ve Kaya ve diğerleri (2019) tarafından geliştirilen RFN Anketi fen bilimleri öğretmenlerine uygulanmıştır. Görüşmelerden ve anketten elde edilen veriler sırasıyla tematik analiz ve betimsel istatistiklerle analiz edilmiştir. Araştırmanın bulguları, Türkiye'deki fen bilimleri dersi öğretim programının bilimin sosyal-kurumsal sisteminden çok bilişsel-epistemik sistemine atıfta bulunduğunu göstermiştir. Fen bilimleri dersi öğretim programında bilimsel pratikler kategorisi en yüksek kod sıklığına sahipken, politik güç yapıları kategorisi en az kod sıklığına sahiptir. Fen bilimleri öğretmenlerinin RFN Anketine göre RFN anlama düzeyleri orta ve yüksek düzeyde bulunmuştur. Ancak görüşmelerde öğretmenlerin bazı RFN kategorileri hakkında naif görüşler ve sınırlı bilgi sergiledikleri görülmüştür. Fen bilimleri öğretmenleri, bilimin doğasının fen bilimleri dersi öğretim programına daha fazla entegre edilmesini ve bilimin doğası ile ilgili kaynakların artırılmasını önermişlerdir. Bu çalışmanın, RFN'nin fen bilimleri öğretim programına dahil edilmesi ve RFN'nin öğretmen eğitimine entegrasyonu için önerileri vardır.

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LIST OF ACRONYMS/ABBREVIATIONS

AV	Aims and Values
EA	Educational Applications
FRA	Family Resemblance Approach
FS	Financial Systems
H	High Level RFN Understanding
M	Moderate Level RFN Understanding
M	Methods and Methodological Rules
MEB	Milli Eğitim Bakanlığı
NOS	Nature of Science
PA	Professional Activities
PPS	Political Power Structures
PRI	Private School
PU	Public School
RFN	Reconceptualized Family Resemblance Approach to NOS
SCD	Social Certification and Dissemination
SE	Scientific Ethos
SK	Scientific Knowledge
SIA	Social-Institutional Aspects
SOI	Social Organizations and Interactions
SP	Scientific Practices
SV	Social Values

1. INTRODUCTION

The title of this research which is “The inclusion of the NOS in Turkish science curriculum” implies not only NOS in the curriculum but also science teachers’ views of NOS and curriculum. To explain the extent of the title, a triangle analogy can be made. Like three corners of a triangle, the title of the research consists of three main components. The corner at the top is the inclusion of NOS in the curriculum as indicated in the title. Although the other two corners related to science teachers were not emphasized in the title, they are touchstones of the curriculum implementation. In other words, without teachers’ NOS and curriculum views, the NOS in the curriculum is not enough to create an effective learning environment. It's like a single corner can't form a triangle. On the other hand, compounding these corners with sides is the researcher’s duty as in this thesis.

In science education, Nature of Science (NOS) is one of the fundamental topics. Therefore, NOS has attracted attention as a research area in science education throughout history (Erduran & Dagher, 2014a). The researchers in the field defined the NOS many times in different ways. Although there is not a common definition of NOS among the science experts, “typically, the NOS has been used to refer to the epistemology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge” (Abd-El-Khalick *et al.*, 1998, p.418). In other words, understanding of the NOS means to understand the core of science.

What makes NOS valuable in science education is a critical question that should be asked by science educators. Driver *et al.* (1996) answered this question by determining some arguments such as “Utilitarian”, “Democratic”, “Cultural”, “Moral”, and “Science learning” arguments. With the help of these arguments, the importance of the NOS in science education is more understandable for teachers, students, and academicians in the field. Respectively, the meanings of the “Utilitarian”, “Democratic”, “Cultural”, “Moral”, and “Science learning” arguments are mentioned. According to Driver *et al.* (1996)’s utilitarian argument, understanding NOS is important because it provides that people realize scientific developments and manage technological developments in daily life. In other words, the teaching of the NOS makes the citizens scientifically and technologically literate in order to be able to follow scientific and technological improvements. Irzik and Nola (2014) also supported the idea that scientific literacy is interrelated with the NOS understanding. The democratic argument that matters the significance of NOS in science education supports the idea that NOS causes to increase in the number of decision-makers in socio-scientific issues. Understanding NOS enables people to think, interpret, and discuss socio-scientific issues critically. Driver *et al.* (1996)'s cultural view indicates that understanding NOS gives value to science in cultural societies. In other words, science gains an importance in contemporary cultures with the help of the NOS. Moreover, moral argument states that learning NOS provides to learn the norms in scientific communities. This means that in science, ethical considerations have a critical importance and NOS makes them more understandable for science education. The last argument is about learning of the science content. As a result, science is not only a knowledge block for elites but also the realization of nature for all. Furthermore, the internalization of the meaning and structure of NOS makes the societies' prosperity high. Therefore, the teaching of the NOS should be considered in science education.

There are many perspectives that look at NOS from different angles in the related literature (Irzik & Nola, 2014). Each of the perspectives focuses on the certain aspects of the NOS that change during the history. From past to present, ''Consensus View'' (Abd-El Khalick & Lederman, 2000), ''Whole Science'' (Allchin, 2011), ''Features of Science (FOS)'' (Matthews, 2012), and "Family Resemblance Approach (FRA) to NOS" (Irzik & Nola, 2014) have taken attention in the literature related to NOS in science education. Each of these perspectives criticized the previous ones due to their narrow viewpoints, and extended the context of the NOS. For instance, consensus view sees NOS within the limited seven principles. The seven principles of consensus view are about the laws and theories, observation and inference, scientific method, and aspects of scientific knowledge (Lederman *et al.*, 2002). The most current perspective was developed from the "Family Resemblance Approach (FRA) to NOS" that categorizes science as cognitive-epistemic and social-institutional systems.

FRA was adapted to NOS from Wittgenstein's family resemblance idea by Irzik and Nola (2014). In Irzik and Nola's (2014) FRA to NOS version, science was separated as cognitive-epistemic and social-institutional systems that include eight categories in total even though these categories have many junction points. “Process of inquiry, aims and values, methods and methodological rules, and scientific knowledge” are the categories of the cognitive-epistemic system of FRA to NOS while “professional activities, scientific ethos, social certification and dissemination of scientific knowledge, and social values” are the categories of social-institutional system of FRA to NOS (Irzik & Nola, 2014). On the other hand, while Erduran and Dagher (2014a) reconceptualized the Irzik and Nola’s FRA to NOS by adding new categories and developing some images and educational applications, Kaya and Erduran (2016a) used the term of the “Reconceptualized FRA-to-NOS (RFN)” in short. The terminology of the RFN differentiates the FRA in education from the other using areas such as philosophical counterparts (Kaya *et al.*, 2019).

During the reconceptualization of the FRA to NOS in science education, some shortcomings were realized in Irzik and Nola’s (2014) FRA to NOS version. For example, in addition to four categories of social-institutional systems, three more categories that are “social organizations and interactions”, “political power structures”, and “financial systems” were added to the new version (Erduran & Dagher, 2014a). Moreover, the category of “process of inquiry” in Irzik and Nola (2014)’s version was altered as the category of “scientific practices”. As a result, in Erduran and Dagher (2014a)’s FRA to NOS version, the cognitive-epistemic system consists of “aims and values”, “methods and methodological rules”, “scientific practices”, and “scientific knowledge” while the social-institutional system consists of “scientific ethos”, “professional activities”, “social values”, “social certification and dissemination”, “social organizations and interactions”, “political power structures”, and “financial systems”. One of the most fundamental advantages of the RFN is to be a holistic perspective including interactions among the categories. Also, the RFN is pedagogically applicable in classrooms with the help of visual images. In the study, the term of the RFN is mentioned as the study’s theoretical framework.

Even though the RFN is a recent perspective, it has a considerable place in the science education literature. For instance, there are studies conducted with students (e.g. Akbayrak & Kaya, 2020; Çilekrenkli, 2019; Goren, 2021), pre-service teachers (e.g. Erduran & Kaya, 2019; Erduran *et al.*, 2021; Kaya *et al.*, 2019), teachers (e.g. Aksoz, 2019; Azninda *et al.*, 2021), and textbooks (e.g. BouJaoude *et al.*, 2017; Okan, 2021; Park *et al.*, 2020). Moreover, curriculum analyses were conducted with the RFN perspective (e.g. Kaya & Erduran, 2016b; Yeh *et al.*, 2019). However, it is necessary to increase the number of the curriculum analysis that investigated the curriculum from the RFN perspective in order to have a holistic science understanding in schools.

According to the OECD report (2020), even though the curriculum is defined in different ways and a more detailed definition is necessary, it can be identified as the experiences that students gain in a school environment. In other words, the curriculum is a plan that teachers apply to gain students experiences under the school roof. On the other hand, according to Stenhouse (1975), curriculum is "an attempt to communicate the essential principles and features of an educational proposal in such a form that it is open to critical scrutiny and capable of effective translation into practice" (p.4). This definition implies that the curriculum has a translation in the implementation. Moreover, Stenhouse (1975) mentioned a curriculum that is expected to be applied in schools and a curriculum that is applied in schools in reality.

The curriculum should not be thought independent from teachers and students. Therefore, there might be a difference between the expected and real curriculum. According to Tan-Sisman (2021), the curriculum is not only a written document because it is affected from the factors of a teacher and student in a real classroom environment. It can be mentioned 3 types of curricula that are "intended (written)", "implemented (taught)", and "attained (achieved)" curriculum. While the intended (written) curriculum consists of official standards that include what students should know, the implemented (taught) curriculum consists of how these standards are implemented in classrooms (OECD, 2020). Furthermore, the attained (achieved) curriculum shows what students learned as a result of the intended and implemented curriculum (OECD, 2020). Most of the time, it was found that a gap exists between the intended (written) curriculum and implemented (taught) curriculum due to the differentiation among implementation processes. However, it is significant that the intended (written) curriculum is aligned with the implemented (taught) curriculum to have a successful curriculum (Karabacak & Kurum-Yapıcıoglu, 2020).

Curricula are separated as national curricula that governments are responsible and school-based curricula that schools individually are responsible (Kaya *et al.*, 2012). In

Turkey, national curricula for each subject and level are used. It means that all students at the same grade level have common learning objectives in the boundaries of Turkey without looking at any differences. The most recent science-related curricula started to be used in 2018. For the science curriculum, primary school from the 3^{rd} to 4^{th} grade and the middle school from 5^{th} to 8^{th} grade share the same curriculum (MEB, 2018a). On the other hand, the high school science curriculum from 9^{th} to 12^{th} grade differentiates as physics (MEB, 2018b), chemistry (MEB, 2018c), and biology (MEB, 2018d) disciplines. In Turkish science, physics, chemistry, and biology curricula, there are sections that show objectives and topics based on the different grades. On the other hand, the implementation of the curricula mostly changes from teacher to teacher and student to student in Turkey although they are national curricula. This situation was emphasized in the recent Turkish science curriculum as an expectation from teachers. In other words, teachers are expected to make adaptations during the implementation of aims and objectives in the science curriculum (MEB, 2018a). Livingstone (1986) supported this idea by seeing teachers as gatekeepers of the curriculum. This means that teachers have a right to decide how, when, and to what extent the lesson is taught by paying attention to the border of the curriculum (Livingstone, 1986). Thus, a wide gap appears between the curriculum that the developers intended and the curriculum that students achieved.

Based on the studies, NOS should be mentioned more in science education like scientific knowledge (Osborne *et al.*, 2003). In order to succeed it, science-related curricula should include NOS more. The integration of the NOS to the science-related curricula leads students to internalize science in detail. According to Kaya and Erduran (2016a), NOS is one of the main goals that take place in curricula for decades. Additionally, NOS is the main part of the science standards (e.g. NGSS Lead States, 2013). Therefore, the number of the national and international studies that investigated inclusion of the NOS in science-related curricula is high in the literature (e.g. Izci, 2017; Leden & Hansson, 2015; Ozden & Cavlazoglu, 2015). There are also some recent studies that focused on the inclusion of the NOS in science-related curricula. These studies used the RFN as a framework because it was a recently developed holistic approach. Kaya *et al.* (2017) said that the holistic approach is important to teach NOS from different categories based on the studies in different science topics. Cheung (2020) analyzed the Hong Kong biology curriculum while Yeh *et al.* (2019) analyzed two Taiwanese science curricula in terms of the RFN categories. Additionally, Turkish science curricula (MEB, 2006; MEB, 2013) were also investigated in the scope of the RFN (Kaya & Erduran, 2016a). As a common result of curriculum analyses, it was found that the social-institutional aspects of NOS were limited in contrast to cognitive-epistemic aspects of NOS. The studies that focused on the inclusion of the RFN on science-related curriculum have significance because it is beneficial for the understanding of NOS in science education holistically. However, there is a limited amount of research including curriculum analysis with the focus of the RFN. Therefore, the purpose of the study is to analyze the recent Turkish science curriculum based on the RFN perspective.

In addition to the importance of the curriculum, the practitioners of the curriculum who are teachers should also be considered in order to teach NOS. In other words, not only the inclusion of the RFN on the curriculum but also the views of teachers about the RFN and curriculum are critical components for students' understanding the science as a whole. Moreover, the views of the teachers are significant because there are differences among teachers' curriculum implementations that affect students' understandings. According to Azninda *et al.* (2021), students' NOS understandings can be affected from the teachers' views of NOS. Therefore, it is important to learn the teachers' RFN and curriculum views in order to understand how teachers interpret the RFN and curriculum. In Turkey, science course in primary school is given by primary school teachers while other science-related courses are given by specialized teachers who are science, physics, chemistry, and biology teachers. It is important for science teachers to have knowledge of NOS so that students can understand the RFN categories in detail and look at science in a holistic way. Even though there are many studies related to pre-service teachers' RFN understanding, the number of studies related to teachers' RFN understanding is limited or deficient. For example, Aksoz (2019) worked on only the aims and values category and social-institutional categories of the RFN. According to Aksoz (2019)'s results, it was found that the views of teachers towards the RFN were limited. Whereas, students' NOS understanding might depend on their teachers' views of NOS. Therefore, the number of research that is conducted about the RFN views of teachers should be increased. In this study, science teachers' views of the RFN and curriculum take place as well as the analysis of the RFN inclusion in the science curriculum.

1.1. Purpose of the Study

The purpose of the study is to analyze the inclusion of the NOS in the Turkish science curriculum from the RFN perspective through content analysis. The science curriculum that was analyzed in the study is the most recent science curriculum that has been used in Turkey (MEB, 2018a). Additionally, another purpose of the study is to determine science teachers' views of the RFN and the science curriculum.

1.2. Significance of the Study

There are many studies that focused on NOS in science education. The NOS is a significant topic for science education because understanding of NOS makes students effective citizens both locally and globally (Smith & Scharmann, 1999). Because of the popularity of NOS, many perspectives investigating NOS in science education came out. The "consensus view", "whole science", "feature of science", and "family resemblance approach to NOS" are the examples of these perspectives. The most recent approach is the RFN rising from "family resemblance approach to NOS" and includes cognitive-epistemic and social-institutional categories of science (Erduran & Dagher, 2014a).

The RFN is significant because it enables persons to understand science contextually and holistically (Erduran and Dagher, 2014a). Moreover, the RFN presents the pedagogical applications that can be used in classrooms easily. However, because the RFN is a new approach in the literature, more studies are needed in the science education context. Therefore, this study's theoretical framework is based on the RFN. The previous studies focusing the RFN were conducted with the middle school students (e.g. Akbayrak & Kaya, 2020; Alayoglu, 2018; Çilekrenkli, 2019), university students (e.g. Akgun, 2018; Akgun & Kaya, 2020), pre-service teachers (e.g. Erduran *et al.*, 2021; Kaya *et al.*, 2019; Saribas & Ceyhan, 2015), and in-service teachers (e.g. Aksoz, 2019; Azninda *et al.*, 2021). Additionally, there are textbook analyses (e.g. BouJaoude *et al.*, 2017; McDonald, 2017; Park *et al.*, 2020) and curriculum analyses (e.g. Erduran & Dagher, 2014b; Kaya & Erduran, 2016a; Kaya & Erduran, 2016b; Yeh *et al.*, 2019) that looked at the documents from the RFN perspective.

Although the studies related to the NOS and curricula are in high number (e.g. Izci, 2017; Leden & Hansson, 2015; Ozden & Cavlazoglu, 2015), the studies related to the RFN and curriculum should be increased. According to Kaya and Erduran (2016a), curriculum analysis from the RFN perspective is quite limited. Whereas the investigation of the science curriculum in the scope of the RFN is critical in order to determine the shortages in the curriculum and redesign it based on the RFN framework (Kaya & Erduran, 2016b). This study has a potential to decrease the gap about curriculum analysis in the context of the RFN and has an importance to inform the policy makers and curriculum designers. With the help of the inclusion of the RFN into the science curriculum, students' NOS understanding might be improved and they might become scientifically literate citizens. In other words, the science curriculum has a power to make students' RFN understanding more meaningful. Because of that, NOS should take place in the science curriculum inclusively. This study is significant because it aims to investigate the inclusion of the RFN in the Turkish science curriculum. In some previous studies conducted within the RFN framework, all categories of the RFN were not included. However, in this study, the science curriculum was investigated by taking into consideration of all categories of the RFN consisting of cognitive-epistemic and social-institutional categories. The RFN categories have an importance to improve students' cognitive abilities and social awareness (Kaya *et al.*, 2017). Because of that, to focus on all categories of the RFN as a whole is important. Moreover, analyzing the recently developed Turkish science curriculum (MEB, 2018a) in the context of the RFN is necessary because this curriculum is now used in science lectures as a main document by science teachers.

This study also differs from the relevant literature because it includes the views of science teachers towards science curriculum and the RFN in contrast to previous curriculum content analysis studies. The views of the teachers are valuable to teach the RFN because they are practitioners of the curriculum in classrooms. In other words, the inclusion of the RFN in science curriculum is not enough to transmit the RFN to the students. It is necessary to have competent science teachers in the scope of the RFN. Before achieving this aim, their views about the RFN and curriculum should be investigated. Science teachers' RFN views were analyzed in the study after collecting data from the participants in addition to the science curriculum analysis.

1.3. Research Questions

- To what extent does the Turkish science curriculum include the Reconceptualized Family Resemblance Approach to Nature of Science (RFN)?

- What are the science teachers' views of the RFN and the Turkish science curriculum?

1.4. Definitions of Key Terms

- Nature of Science (NOS): "The epistemology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge" (Abd-El-Khalick *et al.*, 1998, p.418). According to Erduran and Dagher (2014a), science is a totality of cognitive-epistemic and social-institutional categories.

- Reconceptualized Family Resemblance Approach to NOS (RFN): It is a recent perspective that reconceptualized Irzik and Nola's (2014) "Family Resemblance Approach (FRA) to NOS" on science education designing by Erduran and Dagher (2014a) and entitling by Kaya and Erduran (2016a). New categories showing aspects of science were added to the existing FRA to NOS categories. In the end, the RFN consists of 11 categories that include cognitive, epistemic, and social-institutional categories of science.

- Aims and Values of Science (AV): Erduran and Dagher (2014a) defined aims and values of science in the context of the cognitive, epistemic, and social aspects. While cognitive-epistemic aspects of science can include objectivity, consistency, novelty, and accuracy, social aspects can include honesty, decentralizing power, and addressing human needs (Erduran & Dagher, 2014a).

- Scientific Practices (SP): The "benzene ring" analogy was used to symbolize the six components of scientific practices by Erduran and Dagher (2014a). Activities, real world, prediction, explanation, model, and data are the scientific practices

(Erduran & Dagher, 2014a). In the center of the benzene ring, representation, reasoning, discourse, and social certification take place to describe the social environment of the components (Erduran & Dagher, 2014a).

- Methods and Methodological Rules of Science (M): The “gears” image analogy shows the hypothesis testing, non-hypothesis testing, manipulative, and non-manipulative description as methods and methodological rules for explanatory consilience (Erduran & Dagher, 2014a).

- Scientific Knowledge (SK): Erduran and Dagher (2014a) determined theories, laws, and models (TLM) as the kinds of scientific knowledge. These components work collaboratively to create or confirm a new knowledge (Erduran & Dagher, 2014a).

- Social-Institutional Systems of Science (SI): It is one of the categories of science and involves scientific ethos, social certification and dissemination, professional activities, social values, financial systems, political power structures, and social organizations and interactions (Erduran & Dagher, 2014a).

- Social Certification and Dissemination (SCD): It is a kind of process that scientists investigate and confirm the scientific knowledge via peer-review journals, and then present the scientific knowledge in the conferences (Erduran & Dagher, 2014a; Erduran *et al.*, 2021).

- Scientific Ethos (SE): It is the norms that scientists follow during the scientific implementation. Erduran and Dagher (2014a) exemplified the scientific ethos as honesty, respect for human beings, animals, and environment.

- Social Values (SV): Erduran and Dagher (2014a) gave freedom, respect, and social utility as examples of social values of science.

- Professional Activities (PA): Scientists perform some professional activities such as attending conferences, reviewing papers, and presenting the research results in addition to conducting research (Irzik & Nola, 2014).

- Social Organizations and Interactions (SOI): Scientists have interactions with each other while they are working in institutions such as research centers and universities (Erduran & Dagher, 2014a; Erduran *et al.*, 2021).

- Financial Systems (FS): Scientific research is related to the economic resources closely (Erduran & Dagher, 2014a; Erduran *et al.*, 2021).

- Political Power Structures (PPS): In scientific communities, there are political dynamics that are followed by scientists which are related to the race, gender, governments' ideologies, and hierarchies in the scientific community (Erduran & Dagher, 2014a; Erduran *et al.*, 2021).

- Curriculum: "Although curriculum may be very broadly defined as the totality of the learning experiences of students at school, it is, in fact, a complex, multidimensional phenomenon, and a more nuanced definition is necessary" (OECD, 2020, p.11).

2. LITERATURE REVIEW

In this chapter, first, the place of the NOS in science education is explained by giving the definition of the NOS and perspectives towards the NOS. The criticisms against the NOS perspectives are also mentioned. Secondly, the theoretical framework of the study that is the "Reconceptualized Family Resemblance Approach to Nature of Science (RFN)" is presented with the features and categories. After that, RFN-based studies in science education are provided. Furthermore, because the focus of the study is the science curriculum in the context of the NOS, the international and national studies including curriculum analysis in the NOS context are presented, respectively. Lastly, the studies conducted to explore teachers' NOS views and curriculum implementations are discussed. Then, the chapter ends with the summary section.

2.1. Nature of Science (NOS) in Science Education

Defining NOS with a single sentence is hard because the NOS includes many categories of science in it. On the other hand, there are some NOS definitions that were cited more in the literature. According to McComas *et al.* (1998), NOS is an intersection field of the history, philosophy, sociology, and psychology research areas and examines the meaning of science, science's working style, relationships among scientists, and societies' reactions to the science. This means that NOS is a common point of some science studies dealing with not only scientific concepts but also scientific processes. Abd-El-Khalick *et al.* (1998) define the NOS as a core of science, the way of knowing, or principles during scientific knowledge improvement. As the definition implies, NOS looks at the science from a general perspective. To understand the NOS in detail, historical change of the NOS in literature should be investigated. There are many views that look at the NOS from different angles. "Consensus view" (Abd-El-Khalick & Lederman, 2000), "whole science" (Allchin, 2011), and "features of science" (Matthews, 2012) are the most basic views of NOS. It will be started with the explanation and criticisms of consensus view.

"Consensus View" is one of the common perspectives of the NOS. According to consensus view, there are seven tenets that define the aspects of the NOS. The difference between laws and theories, the difference between observation and inference, the creativity of scientific knowledge, the theory-laden aspect of scientific knowledge, social and cultural aspect of scientific knowledge, tentativeness of scientific knowledge, and the scientific method are emphasized in the consensus view (Lederman *et al.*, 2002). While law means statements that make relationship among observable phenomena, theory means explanations of these phenomena (Lederman *et al.*, 2002). Moreover, while observation is related to the senses, inferences are not related to senses (Lederman *et al.*, 2002). On the other hand, according to Lederman *et al.* (2002), scientific knowledge is a product of human creativity, is changeable, and is affected from scientists' background and culture. Furthermore, there is a myth that only one scientific method is followed to reach true knowledge (Lederman *et al.*, 2002). Most of the science educators accepted the idea that the seven tenets in the consensus view are important. However, at the same time, consensus view was criticized because of its shortcomings.

Opponent views and deficiencies of the consensus view are presented. Irzik and Nola (2011) provided three arguments that showed the deficiencies of the consensus view. The first one was that the consensus view shows the limited vision of science (Irzik & Nola, 2011). This means that aims of science and methodological rules in science have not been mentioned in the consensus view (Irzik & Nola, 2011). Second argument was that the consensus view ignores the differences among different scientific disciplines by looking at the uniform perspective (Irzik & Nola, 2011). The last argument of Irzik and Nola (2011) was that consensus view has insufficient systematic unity. Like in Irzik and Nola's criticism, Matthews (2012) criticized the consensus view due to the narrow viewpoint. This means that the consensus view was limited with the seven tenets although the list of the features of science can continue (Matthews, 2012). Therefore, it is also necessary to understand the NOS with its other aspects. Yacoubian (2012) also provided some critiques against the consensus view of NOS in science education. One of the criticisms about the consensus view was the deficiency on applying the NOS ideas for different purposes such as socio-scientific issues (Yacoubian, 2012). Another criticism was that the consensus view shows a distorted picture about the NOS content and process (Yacoubian, 2012). The final problem related to consensus view in school science was how NOS can be implemented at different grades (Yacoubian, 2012). Whereas, the teaching of the NOS in science lessons has critical importance to understand the science as a comprehensive.

"Whole Science" is another view that explained the NOS. It includes the epistemic and cultural values of science as a comprehensive way (Allchin, 2011). The epistemic values are important for the scientific methods while the cultural values are related to the work of scientists (Allchin, 2011). Allchin (2011) added the concepts of "the peer review, cognitive bias, funding, fraud, validation of new methods, and motivation" to the whole science because he thought that the list of the consensus view ignored these concepts. Moreover, in the whole science, there is a transformation from the declarative tenets of the consensus view to the functional analysis in real life contexts (Allchin, 2011). In addition to the whole science, the features of science will be mentioned as a perspective that investigated the NOS.

Matthews (2012) changed the terminology of "Nature of science" to the "Features of science" and added new tenets to the consensus view. "Experimentation", "idealization", "models", "values and socio-scientific issues", "mathematisation", "technology", "explanation", "worldviews and religion", "theory choice and rationality", "feminism", "realism and constructivism" are the new categories of features of science (Matthews, 2012). With these categories, Matthews (2012) emphasized the other features of science that are epistemology, sociology, history, technology, psychology, and economy in addition to the ones in the consensus view. Although Matthews explained the reasons of extension in features of science in a meaningful way, he did not explain why these features were selected, not others (Erduran & Dagher, 2014).

Lastly, Irzik and Nola (2011, 2014)'s "Family Resemblance Approach (FRA) to NOS" is the alternative approach to the previous perspectives in the context of the NOS. The idea of Family Resemblance firstly was developed by Ludwig Wittgenstein to use in philosophical areas. Then, it was adapted to use in the NOS context (Irzik & Nola, 2014). As mentioned earlier, Irzik and Nola (2011) criticized the consensus view due to the narrow point of view. Therefore, the idea of FRA to NOS covers science as more holistic and systematic unities in contrast to the consensus view (Irzik & Nola, 2014). This means that FRA to NOS conceptualized science as cognitive-epistemic and social-institutional categories (Irzik & Nola, 2014). While the cognitive-epistemic categories consist of "process of inquiry", "aims and values", "methods and methodological rules", and "scientific knowledge", social-institutional categories consist of "professional activities", "scientific ethos", "social certification and dissemination of scientific knowledge", and "social values" (Irzik & Nola, 2014).

Erduran and Dagher (2014a) added new categories into the Irzik and Nola's FRA to NOS framework and made the framework applicable in science education by interactive models. Then, Kaya and Erduran (2016a) entitled this framework as the "Reconceptualized Family Resemblance Approach to NOS (RFN)". The RFN forms the theoretical basis of the study. In the next section, more information about the RFN is provided.

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

While Erduran and Dagher (2014a) reconceptualized Irzik and Nola (2011)'s "Family Resemblance Approach to NOS", Kaya and Erduran (2016a) used the terminology of the "Reconceptualized FRA-to-NOS (RFN)" to define new version. The RFN is a meta-level approach that explains the NOS comprehensively. In other words, the RFN is a holistic perspective that covers the cognitive-epistemic and social-institutional aspects of science. Additionally, the RFN provides pedagogical applications that can be used in K-12 education. Therefore, using the RFN in educational materials such as curricula and textbooks makes the students' NOS understanding easier. Unlike Irzik and Nola's FRA to NOS, in this new version, the category of "process of inquiry" was changed with the category of "scientific practices" and textual format was ignored. Additionally, Erduran and Dagher (2014a) extended the social-institutional system with three additional categories that are "political power structures", "financial systems", and "social organizations and interactions". Within the RFN framework, Erduran and Dagher (2014a) presented a concentric circle that shows the cognitive-epistemic and social-institutional systems of science holistically.

The concentric circle named as "FRA Wheel" (Figure 2.1) consists of three layers. In the center of the concentric circle, cognitive-epistemic system of NOS is shown with the categories that are “aims and values”, “methods and methodological rules”, “scientific practices”, and “scientific knowledge”. On the other hand, the other two layers depict the social-institutional system of NOS that consist of “social values”, “social certification and dissemination”, “professional activities”, “scientific ethos”, “financial systems”, “political power structures”, and “social organizations and interactions”. There are in total 11 categories of which four are for cognitive-epistemic system and seven are for social-institutional system. Furthermore, there are pores among categories that mean possible movement among categories as shown in Figure 2.1.

Figure 2.1. FRA Wheel: Science as a Cognitive-Epistemic and Social-Institutional System. Source: [Erduran & Dagher, 2014, p. 28].

In the next sub-sections, the categories in the FRA wheel that are “aims and values of science”, “methods and methodological rules”, “scientific practices”, “scientific knowledge”, and seven social-institutional systems of science categories that are “professional activities”, “scientific ethos”, “social certification and dissemination”, “social values”, “social organizations and interactions”, “political power structures” and “financial systems” are explained, respectively.

2.2.1. Aims and Values of Science

Erduran and Dagher (2014a) investigated aims and values of science from a lot of perspectives such as “epistemic”, “cognitive”, “cultural”, “social”, “political”, “moral”, and “ethical” perspectives. They also presented an image that shows epistemic, cognitive and social aspects of aims and values of science (Figure 2.2). Based on the triangular image, the distinctiveness of these aspects is hard and the boundaries between the aims and values are continuous and blurry (Erduran & Dagher, 2014a). Additionally, ethical and moral dimensions were excluded deliberately in the image as in the view of Irzik and Nola (2011). This is because ethical and moral issues are not seen as the purpose of science. Instead of that, they are important principles that are related to the cultural and political way of science and should be followed by scientists (Erduran & Dagher, 2014a).

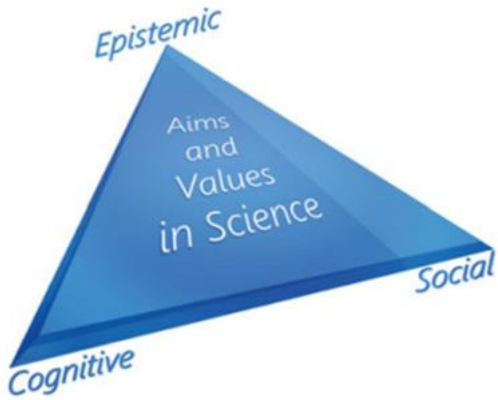

Figure 2.2. Aims and Values in Science. Source: [Erduran & Dagher, 2014a, p. 49].

Erduran and Dagher (2014a) also presented the terminology for the aims and values in science with the educational applications as seen in Table 2.1. While “objectivity”, “novelty”, “accuracy”, “empirical adequacy”, “critical examination”, “addressing anomalies and counter instances”, and “taking challenges seriously” are the using concepts for the epistemic-cognitive aims and values of science, “addressing human needs”, “decentralizing power”, “honesty”, and “equality of intellectual authority” are the using concepts for the social aims and values of science (Erduran & Dagher, 2014a). Furthermore, educational applications of aims and values of science take place in Table 2.1. For instance, in the epistemic-cognitive aims and values of science, the novelty was exemplified as producing new explanations while in the social aims and values of science, the honesty was exemplified as being honest in scientific activities.

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	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

Erduran and Dagher (2014a) believed that the aims and values of science should be attached importance in science lectures because of three reasons. One of the reasons is that students should know the working principles of scientific knowledge and practices by taking into consideration of common values. Another reason is the necessity of the gaining of epistemic values of science by teaching methods including scientific content and practices. Lastly, teaching aims and values is important for students because it provides awareness that bias can appear in the context of the knowledge transmission and investigation.

2.2.2. Methods and Methodological Rules

There is a popular depiction that shows the steps in the scientific method. Erduran and Dagher (2014a) opposed to this depiction that includes "asking a question", "doing background research", "constructing a hypothesis", "testing of hypothesis by doing experiments", "analyzing the data and drawing conclusion", and "reporting results". This is because scientist follows a lot of scientific methods while investigating their research questions instead of the scientific method. Therefore, this depiction is problematic. Moreover, Lederman *et al.* (2002) mentioned the perception of the scientific method as a big misconception that even is explained in textbooks and lectures because there are many scientific methods that scientists follow to reach knowledge. If different kinds of scientific methods are not emphasized, non-experimental methods may be perceived as worthless (Erduran & Dagher, 2014a). This means that knowledge comes from the non-experimental methods can be seen as untrustworthy. Whereas, a student can easily learn that astronomers use non-experimental methods by testing their hypothesis while they are investigating stars (Erduran & Dagher, 2014a). Therefore, Erduran and Dagher (2014a) presented the gear image (see Figure 2.4) that depicts the "manipulative", "non-manipulative", "hypothesis testing" and "non-hypothesis testing" methods. In other words, observational and experimental kinds of scientific methods were shown in the image by emphasizing their working mechanisms as synergetic. Based on the using evidence in a study, the size of the gears in Figure 2.3 can be changed (Erduran & Dagher, 2014a).

Figure 2.3. The 'Gears' Image Illustrating How Evidence from a Variety of Methods Works Synergistically to Contribute to Explanatory Consilience. Source: [Erduran & Dagher, 2014a, p. 101].

2.2.3. Scientific Practices

Erduran and Dagher (2014a) emphasized the classification, observation, and experimentation when explaining scientific practices. According to them, scientific practices consist of epistemic, social-institutional, and cultural dimensions (Erduran & Dagher, 2014a). The meaning of scientific practices is "the set of epistemic and cognitive practices that lead to scientific knowledge through social certification" (Kaya & Erduran, 2016a, p.1123). Furthermore, National Research Council (NRC) (2012) defined the practices as practices that scientists use during knowledge construction about the world and engineers use in their working processes. Also, NRC (2012) suggested eight practices for K-12 students' curricula. These practices 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". This situation implies that scientific practices start to become a main component of science education.

Erduran and Dagher (2014a) presented the main aspects of the scientific practices with the benzene ring analogy (Figure 2.3). In the benzene ring analogy, while carbon atoms refer to the epistemic and cognitive categories of science that are "real world", "explanation", "model", "prediction", "activities", and "data", the electron cloud refers to the social category of science that are "representation", "discourse", "reasoning", and "social certification". As a result, in the image, it was emphasized that there are interactions among the epistemic and cognitive aspects of science, and the social aspect of science affects them.

Figure 2.4. "Benzene Ring" Heuristic of Scientific Practices. Source: [Erduran & Dagher, 2014a, p. 82].

2.2.4. Scientific Knowledge

Erduran and Dagher (2014a) indicated that Theories, Laws, and Models (TLM) are the components of the scientific knowledge and they generate a new scientific knowledge by working together. In other words, theories, laws and models are interconnected with each other as shown in the Erduran and Dagher (2014a)'s image (Figure 2.5). For instance, in physics, the thermodynamics theory, laws of thermodynamic, and heat transfer model make a cooperation to explain the concept of heat (Erduran & Dagher, 2014a). Moreover, TLM are the output of the scientific enterprise and domain-specific (Erduran & Dagher, 2014a). On the other hand, while some of the theoretical structures of a paradigm grow and expand to the other context, sometimes a paradigm shift that can cause a new independent knowledge cycle appears (Erduran & Dagher, 2014a).

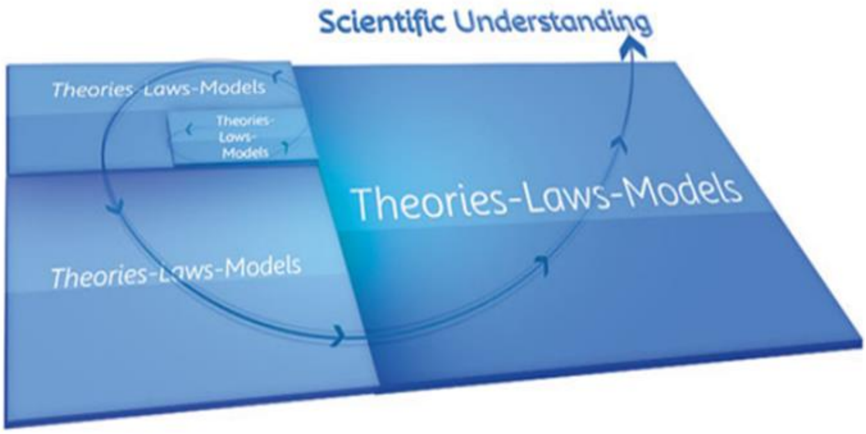

Figure 2.5. TLM, Growth of Scientific Knowledge and Scientific Understanding. Source: [Erduran & Dagher, 2014a, p. 115].

Erduran and Dagher (2014a) indicated that students have learning difficulties in the types of scientific knowledge because these are not taught in schools at a high degree. TLM framework is an effective educational application that can be used in the classrooms. It enables students to understand the validation of particular scientific knowledge, the justification of the scientific knowledge, and the place of the scientific knowledge within and across science disciplines (Erduran & Dagher, 2014a).

2.2.5. Science as a Social-Institutional System

Science is a social system in its nature (Erduran & Dagher, 2014a). Irzik and Nola (2014) provided the four categories such as “professional activities”, “scientific ethos”, “social certification and dissemination of scientific knowledge”, and “social values” in order to represent the aspects of the social system. Then, Erduran and Dagher (2014a) added three more categories that are “social organizations and interactions”, “political power structures", and "financial systems of science" into them. These categories are presented respectively.

Professional activities of scientists are not limited to scientific research that includes knowledge production (Irzik & Nola, 2014). Professional activities that scientists perform are attending conferences, publishing research in a journal, presenting research findings, reviewing proposals, developing projects, seeking funds for research, consulting both public and private institutions, informing the public, and so on (Irzik & Nola, 2014). In other words, these are the routine of scientists. Scientific ethos is defined as the attitudes that scientists have to conform to during their professional activities and in their relationships with other scientists (Irzik & Nola, 2014). Intellectual honesty and integrity, respect for intellectual property, environment, and animal care, and human subjects' protection are the examples of the scientific ethos (Erduran & Dagher, 2014a). Resnik (2005) also mentioned additional ethics in science such as "carefulness", "openness", "freedom", "credit", "legality", and so on. With the help of the ethos in science, knowledge might be more trustworthy and beneficial. Social certification and dissemination is a process that scientists follow after completing their research. They present their works at conferences, review other scientists' works, and publish their articles in the context of this category (Erduran & Dagher, 2014a). Thus, it is made comments, criticisms, and evaluations on the works of scientists with the help of the scientific community to control the quality of the works (Erduran & Dagher, 2014a). Social values refer to "freedom", "respect for the environment", and "social utility" (Erduran & Dagher, 2014a; Irzik & Nola, 2014). Freedom and respect for environment are also take place in the category of scientific ethos. Furthermore, it is necessary that scientists consider the benefits to society and inform societies about the possible results of the studies (Resnik, 2005). The category of social organizations and interactions means that scientists work in social institutions such as research centers, universities, or other scientific institutions including NASA, CERN, TUBITAK, and so on. According to Erduran and Dagher (2014a), political power structures include the relationship between science and government politics, race, and gender. They also stated that the understanding of the politics and science relationship might make students scientific literate by providing critical thinking. Lastly, financial systems control not only scientists' practices but also resources' dissemination (Erduran &

Dagher, 2014a). In other words, financial resources affect the science. Moreover, commodification and commercialization of science are the components of this category.

2.2.6. RFN-Based Studies in Science Education

When looking at the context of the RFN studies, we see the range of research. However, the number of the studies about this framework is relatively low because the RFN is a current perspective. The studies were conducted with the students, pre-service teachers, and teachers to understand the RFN views, perceptions, or levels of them. Additionally, the inclusion of the RFN in textbooks and curricula was analyzed in the literature in a small number. These studies used different terminologies such as “Extended FRA to NOS”, “Expanded FRA to NOS”, and “FRA to NOS” to define the RFN. These studies’ contexts and details are presented within this section and the following ones.

A small number of studies aim to find the RFN understanding of students in the middle school and higher education levels. One of them belongs to Cilekrenkli (2019) who examined the fifth grade students’ NOS understandings in the context of the RFN framework. In the research, the RFN based intervention was applied to the experimental group while usual instruction was applied to the control group. Moreover, both the RFN Student Questionnaire and interviews were conducted to collect data from students. According to the result of the questionnaire, students in the experimental group showed high scores in most of the RFN categories than the students in the control group (Cilekrenkli, 2019). The findings acquired from interviews also supported the results of the questionnaire (Cilekrenkli, 2019).

Akbayrak and Kaya (2020)’s research design and results are similar with the Cilekrenkli (2019)’s study. The study investigated the fifth graders’ RFN perceptions. The most apparent difference of this study from the previous one is to be conducted only in the context of the social-institutional categories of the RFN. Experimental and control groups took place in the study. Pre- and post-tests were implemented to the both of the groups and interviews were conducted with three of the students in the experimental group (Akbayrak & Kaya, 2020). While the experimental group took science lessons including social-institutional categories of science, control group took science lessons with traditional methods at the topic of "The Earth, Sun and Moon" (Akbayrak & Kaya, 2020). As a result, it was found that the experimental group showed higher understanding on social-institutional categories of science than the control group (Akbayrak & Kaya, 2020).

In addition to the studies with middle school students, university students' NOS perceptions within all categories of the RFN were investigated in Akgun and Kaya (2020)'s research. There were two groups that were separated into the science and non-science departments in the research. The RFN Questionnaire and interview were used as data collection methods in the research. Based on the RFN scores of the university students, interviews were conducted with 15 students from the low, moderate, and high levels. The results of the study showed that the university students had limited perceptions about NOS in general (Akgun & Kaya, 2020). Moreover, it was indicated that students from the non-science departments have higher NOS perceptions than students from the science departments (Akgun & Kaya, 2020). Some of the studies focusing on the RFN as a research framework were also conducted to learn pre-service teachers' views about the RFN categories.

Kaya *et al.* (2017)'s research is one of these studies. They implemented 14 weeks training that includes the RFN categories to the 11 pre-service science and four pre-service chemistry teachers in the study. The purpose of the study was to determine the perceptions of the pre-service teachers towards cognitive-epistemic and social-institutional categories of the RFN before and after the implementation. Therefore, mixed-method approach was used in the study. Data sources of the research were the NOS Questionnaire and semi-structured interviews respectively for quantitative and qualitative research designs (Kaya *et al.*, 2017). In the result of the study, it was found that there is a statistically significant difference before and after the implementation on the pre-service teachers' RFN perceptions (Kaya *et al.*, 2017).

Another teacher education study belongs to Saribas and Ceyhan (2015). They conducted a study with pre-service science teachers to improve the teaching in the scope of the scientific practices. The main component of the implementation was Erduran and Dagher (2014)'s Benzene Ring Heuristic (BRH) showing scientific practices. A lot of sources that are interviews, lesson plans, students and teachers' reflections, and lesson audio-tapes were used to collect data for the study. The result of the study showed that the pre-service science teachers' understandings about scientific practices developed even though they had some issues in "domain specificity", "ethics", and "utility in science" (Saribas & Ceyhan, 2015).

The benzene Ring Heuristic (BRH) was also used as a main component in Erduran *et al.* (2018)'s research. Like in the previous studies, a training was implemented for the science teacher candidates to make a comparison between before and after the training. The purpose of the study was to analyze the science teacher candidates' representations about scientific practices. It was found that the candidates were inclined to the holistic representations of scientific practices after the training (Erduran *et al.*, 2018). The findings were parallel with Saribas and Ceyhan (2015)'s study.

As different from the other studies, Kaya *et al.* (2020) carried out a comparative study with Turkish and English prospective science teachers. The study aimed to find the NOS perceptions of the teacher candidates from the RFN perspective by making comparison (Kaya *et al.*, 2020). With the help of the discussions in the groups, the teacher candidates' NOS understandings were analyzed in the research. According to results of the research, both Turkish and English science teacher candidates showed the limited perceptions about the social-institutional categories of NOS (Kaya *et al.*, 2020). On the other hand, it was found that group discussions and using FRA Wheel in discussions had a positive impact on the participants' NOS understanding (Kaya *et al.*, 2020). Textbook analysis in the context of the RFN is another study area that the researchers are interested in.

BouJaoude *et al.* (2017) investigated three Lebanese ninth grade science textbooks from the RFN perspective and gave some advices in their study. Chemistry, life and earth science, and physics textbooks were analyzed with the help of the content analysis (BouJaoude *et al.*, 2017). The findings of the study showed that none of the RFN categories were mentioned in the physics textbook. In addition to the physics textbook findings, it was emphasized that the other two textbooks' NOS inclusion is limited for students' NOS understandings (BouJaoude *et al.*, 2017).

Park *et al.* (2020) reached approximately similar findings with BouJaoude *et al.* (2017)'s study. They analyzed the tasks in seven Korean high school textbooks based on the RFN categories in the research. "Guiding to NOS ideas, expanding NOS understanding, and thinking critically about NOS" are the categories using to separate the tasks about NOS (Park *et al.*, 2020). According to the findings of the study, epistemic aspects of the science were emphasized more than the social aspects of the science.

Another textbook analysis was conducted by McDonald (2017). She analyzed the topic of genetics in four Australian science textbooks in the scope of the extended FRA. According to the findings of the study, it was found that only three emphases of NOS take place explicitly in the textbooks and other ones are emphasized implicitly. Moreover, while scientific knowledge is the only category of extended FRA that took place explicitly in the textbook analysis, aims and values is the only category of extended FRA that did not take place in the textbook analysis.

Sayın (2021)'s research supported the findings coming from previous textbooks studies. The aim of the research was to investigate the extent of the RFN in physics, chemistry, and biology textbooks. She analyzed 12 textbooks for the grades of 9, 10, 11, and 12. During the data analysis, the new keywords about the RFN categories emerged in addition to the keywords in the literature. Based on the findings, it was concluded that the mostly emphasized categories are scientific practices, scientific knowledge, and methodology and methodological rules, respectively. On the other hand, the categories of financial systems and political power structures were emphasized barely in the textbooks.

Different from other studies, Okan (2021) investigated science teachers' RFN perceptions and conducted textbook analysis. The 5^{th}, 6^{th}, 7^{th}, and 8^{th} grade Turkish science textbooks were analyzed in the context of the RFN categories. Also, interviews were conducted with eight science teachers about the NOS and the NOS Questionnaire was presented to them. Textbook analysis findings were parallel with the previous studies. This means that the NOS emphasis in the textbooks was implicit and social-institutional categories of science took place less than the cognitive-epistemic categories. Furthermore, the NOS took place mostly in the activity section of the textbooks. For the teacher part of the study, it was found that the NOS perceptions of science teachers were high with some limited explanations in the categories of SP and M (Okan, 2021).

In addition to the textbook content analysis, curriculum content analysis attracts the attention of researchers who are interested in NOS. However, relatively, there is limited number of the studies that analyzed curriculum in respect to the NOS. The following section presents the importance of NOS for science curricula and to what extent NOS takes place in science curricula by exemplifying with international research.

2.3. Inclusion of Nature of Science (NOS) in Science Curricula

Curricula are at least as important resources for science education as the textbooks. Even, the content of the textbooks are determined based on the curricula's content. At the same time, curricula represent changes in education and these are the mediators among educational reforms and students. Therefore, curricula shape the teachers' instruction in the context of topics, objectives, and time. As a result, students are affected from the curricula content directly. Furthermore, the curricula are shaped on the government, classroom, and student level. Respectively, for these levels, "intended (written)", "implemented (taught)", and "attained (achieved)" curriculum appear. The intended (written) curriculum is the reflection of governments' educational aims for students' learning into the written documents (Cil & Cepni, 2014). In other words, it includes objectives, flow of the course, and so on (Livingstone, 1986). In the implemented (taught) curriculum, the intended curriculum is practiced in the classroom with different teaching methods (Phaeton & Stears, 2016). This means that the teachers' backgrounds, experiences, attitudes, and views can change the applications of the written curriculum. Additionally, the using textbooks and size of the classrooms are the factors that affect the teacher preferences in the implemented (taught) curriculum (Livingstone, 1986). Lastly, the attained (achieved) curriculum means the outcomes that students gained after teaching and learning process (Cil & Cepni, 2014). On the other hand, Connelly and Connelly (2012) say that the practice of curriculum has low fidelity to the curriculum policy. In other words, there is a gap among curricula types. Nevertheless, it should be remembered how much the gap between intended (written) and attained (achieved) curriculum is closed, that much success is obtained in education. Penuel *et al.* (2014) investigated this gap from the perspective of actor-oriented that means the active impact of a teacher on the purpose of the curriculum during instruction.

According to McComas and Olson (1998), there is a consensus among several countries' standards documents about the inclusion of NOS in school science curricula. In other words, the inclusion of NOS in science curriculum is an aim to make the students' more competent about science. Because of that, analyzing science curriculum has a critically essential in order to learn to what extent NOS is included in science curriculum. In the literature, there are some curriculum analyses that investigated the inclusion of NOS in science curricula.

One of the studies aimed to investigate the progression of NOS in the Swedish curriculum (Leden & Hansson, 2015). Also, the science teachers' suggestions about NOS were researched. The curriculum was analyzed based on the Lederman's six tenets such as "tentative, empirical, subjective, creative, sociocultural, and models, theories and laws aspects of NOS" (Leden & Hansson, 2015). According to the findings of the study, a lot of NOS aspects were mentioned in the Swedish national curriculum, at least implicitly. However, any progression was not found in the curriculum in terms of NOS.

Ferreira and Morais (2013) analyzed the Natural Science curriculum in Portuguese middle school in terms of NOS. The two curricular texts of the curriculum that are "National Curriculum for Basic School-Essential Competences" and "Curriculum Guidelines for Basic School" were focused on (Ferreira & Morais, 2013). Mixed methodology that includes quantitative and qualitative approaches was used while analyzing the curriculum. As a result of the study, it was found that the place of the NOS in curriculum is limited except for the external sociological dimension of science. Furthermore, it was stated that intra-disciplinary relationships between scientific and meta-scientific knowledge are mostly not included in the curriculum.

Olson (2018)'s study includes the investigation of nine science standards documents from the NOS perspectives. Each of the documents belongs to the different countries that are Australia, Canada, Colombia, Indonesia, Lebanon, Mexico, Thailand, South Africa, and the USA. Olson (2018) who separated the documents into three sections such as headers, font/back matter, and standards found the number of NOS inclusion as 44, 50, and 18 respectively. Based on the findings, while Australia's document contains NOS more than the other countries' documents, Indonesia's document does not contain NOS at all. Furthermore, it was found that the inclusion of NOS in standards was limited to four documents.

Williams (2018) conducted a case study to explore the development of NOS in the national science curriculum in between 1988-2010. Curriculum and document analysis, as well as semi-structured interviews, were used to collect data. The interviews were conducted with four science teachers in order to learn their teaching experiences that include the applications of different versions of the science curriculum since 1988. The findings of the study showed that the limited NOS in the science curriculum causes limited scientific literacy development.

Erduran and Dagher (2014b) analyzed draft curriculum and assessment documents different from the other studies. In the study, the Irish documents were analyzed based on Erduran and Dagher (2014a)'s recently developed FRA to NOS model. There are some sections such as "physical world, earth and space, materials, and biological world" in the curriculum and it was found that they include some elements of NOS. However, the researchers suggested new additions by taking into consideration the cognitive-epistemic and social-institutional categories of NOS.

Kelly and Erduran (2019) investigated the Irish Junior Cycle science specification that includes learning outcomes in the context of the aims and values of science. Document analysis was used during this process and the keywords in Erduran and Dagher (2014a)'s study were benefited from. They also conducted interviews with two prospective science teachers and presented a survey in order to learn their views about the aims and values of science. According to the findings, most of the social aims and values of science did not take place in this specification. On the other hand, the prospective teachers' suggestions about the aims and values of science were found effective.

Park *et al.* (2020a) conducted a different study by using FRA as a conceptual framework. The study was different from the others because not only the nature of science (NOS) but also the nature of technology (NOT), engineering (NOE), and mathematics (NOM) were included into the curriculum documents analysis. This means that “the Science for All Americans (SfAA)” and “the Next Generation Science Standards (NGSS)” were analyzed in the scope of epistemic category such as aims and values, methods, practices, and knowledge of STEM (Science, Technology, Engineering, and Mathematics). The descriptions and keywords of the FRA categories in Erduran and Dagher (2014a) were adapted to the STEM in order to be used in this study. The findings showed that only epistemic categories of FRA do not take place NGSS in the practices of the NOT and methods of the NOM.

Park *et al.* (2020b)’s study is similar with the previous study. The science education standards documents of USA, Korea, and Taiwan were analyzed in the context of the nature of STEM. Descriptions of all FRA categories that were adapted to the STEM by Park *et al.* (2020a) were benefited in the analysis. The findings were depicted as Venn diagrams showing aims, values, and practices of STEM disciplines. As a result, it was found that the science aspects were focused on more than the mathematics aspects in the standards documents. Additionally, the coverage of the nature of STEM disciplines is more in the USA document.

The inclusion of the NOS in science curriculum was also investigated by Yeh *et al.* (2019). This was a case study that examined two Taiwanese science curriculum documents published in 2006 and 2016. While one of the documents was Science and Technology guideline for grades 1-9, the other one was the Science guideline for the grades 1-12. The FRA was used while analyzing the curricula in the context of the NOS (Yeh *et al.*, 2019). According to the study’s results, the social-institutional categories of the NOS was emphasized more in the 2016 science guideline when comparing with the 2006 science and technology guideline (Yeh *et al.*, 2019). This can be meant that the new Taiwanese science curriculum in 2016 gave more importance to the categories of the FRA.

Moreover, Cheung (2020) conducted a research that investigated Hong Kong biology curriculum and high-stakes assessments in the scope of the NOS. In the research, it was aimed to find the representation of NOS categories in the biology curriculum. When analyzing the documents, Erduran and Dagher (2014a)'s FRA to NOS version was used as a theoretical framework. For the Hong Kong biology curriculum, the sections of "learning targets" and "curriculum emphases" were focused on because the NOS was emphasized in these sections (Cheung, 2020). The results of the study indicated that the cognitive-epistemic categories of the NOS were represented more than the social-institutional categories in the biology curriculum and high-stakes assessments (Cheung, 2020).

As a result, there are some studies that analyze the inclusion of NOS in science curricula from different perspectives such as the consensus view and the RFN. In this section, it was mentioned the ones that were conducted as international. As a general, the findings obtained from these studies showed that the inclusion of the NOS is limited or implicit in the science curricula. Moreover, in these studies, some sections of the curricula in the scope of the NOS were usually investigated instead of whole curriculum. This is because there were limited NOS emphases in the science curricula. Except for the international curriculum analyses, Turkish science-related curricula were analyzed with the NOS perspectives. The details are provided in the next section.

2.4. Inclusion of Nature of Science (NOS) in Turkish Science Curricula

The number of the studies that focused on the inclusion of NOS in Turkish science curricula is relatively low even though science curricula are one of the important documents that affect the students' NOS understandings. Furthermore, in Turkey, science education is presented to the students from 3rd to 12th grades with the national science, physics, chemistry, and biology curricula. Therefore, the studies about NOS and curriculum in the literature always investigate the science, physics, chemistry, and biology curricula. On the other hand, the recent science curriculum (MEB, 2018a) was not investigated in the context of the RFN that is recent version of NOS.

Izci (2017) examined the Turkish science and technology curriculum and textbooks in the context of the NOS. The science and technology curriculum that Izci (2017) analyzed was published in 2006, and it was for the 6, 7, and 8 graders. In that term, the middle school consisted of the 6, 7, and 8 grades in Turkey. In the study, the ten aspects of the NOS (Abd-El-Khalick *et al.*, 2008) were focused by using implicit-explicit approach (Izci, 2017). In the results of the research, it was found that the reflection of NOS is inadequate in science and technology curriculum. According to the Izci's research (2017), while some of the NOS aspects which are inferential and theory-driven were shown implicitly, some of the NOS aspects which are scientific theories and laws were not shown in the 2006 science and technology curriculum.

Ozden and Cavlazoglu (2015) found the similar results with the Izci (2017)'s study in their research. They investigated the inclusion of NOS in Turkish science curricula. Qualitative content analysis was used while investigating 2005 science and technology (Grades 4 and 5), 2006 science and technology (Grades 6, 7, and 8), and 2013 science curricula (Grades 3-8) (Ozden & Cavlazoglu, 2015). Because the introduction sections of the 2005 and 2006 curricula were the same, the researchers decided to investigate these two curricula as whole that named 2005 science and technology curriculum (Grades 4-8) (Ozden & Cavlazoglu, 2015). The data sources were analyzed in the context of the nature of science's definitions, and components. The results of the study indicated that in the curricula, some of the NOS's aspects do not take place explicitly, and the emphasis of the NOS is not enough (Ozden & Cavlazoglu, 2015).

Sardag *et al.* (2014) worked on the 2013 Turkish physics, chemistry, and biology curricula at high school level (Grades 9-12). In the study, the objectives in the curricula were coded by the six researchers based on the NOS aspects. Moreover, explicit-reflective, implicit, and historical codes were used as approaches while content-generic and content-embedded codes were used as content relation (Sardag *et al.*, 2014). According to the results of the study, the NOS emphasis is low in the objectives of the physics, chemistry, and biology curricula. Even, some of the NOS aspects did not take place in these curricula such as imagination and creativity.

In contrast to the previous curriculum studies, Yapıcıoglu (2021) analyzed the recently developed Turkish science curriculum in 2018. It was aimed to investigate the science curriculum in the scope of NOS, science process skills, socio-scientific issues, and Science, Technology, Engineering and Mathematics (STEM). The document was analyzed through the document analysis method and it was limited with the outcomes section of the curriculum. Some of the NOS dimensions that were analyzed were “science as a way of knowing”, “the tentativeness of scientific knowledge”, “the role of imagination and creativity in science”, “subjectivity in science”, “theory and laws as a type of scientific knowledge”, “scientific prediction and theoretical assumptions”, and so on (Yapıcıoglu, 2021). It was found that while the grade level increases, using NOS dimensions increases. However, as a general, limited NOS inclusion in the science curriculum was found. In addition to the place of the previous NOS perspectives on Turkish curricula, the inclusion of the RFN in science curriculum was also analyzed in the Turkish context.

Kaya and Erduran (2016a) analyzed the Turkish 2006 and 2013 science curricula. While the 2006 science curriculum is for the grades 6-8, the 2013 curriculum is for the grades 3-8. In the study, a new terminology was used for the Erduran and Dagher (2014a)’s FRA to NOS that is “Reconceptualized FRA-to-NOS (RFN)” (Kaya & Erduran, 2016a). Therefore, the science curricula were investigated in the context of the RFN categories. The researchers used Erduran and Dagher (2014a)’s FRA to NOS definitions by producing codes for the curriculum analysis (Kaya & Erduran, 2016a). In this study, the focus is on the occurrence of the RFN categories rather than the frequency of the categories. The results of the study indicated that both of the science curricula include the cognitive-epistemic categories of the science (Kaya & Erduran, 2016a). However, the science’s social-institutional categories in the science curricula are underemphasized (Kaya & Erduran, 2016a). Moreover, the results of the Turkish science curricula were compared with the USA and Ireland in the research. According to the results, in the social categories of the RFN, 2013 Turkish science curriculum refers more categories when it was comparing with the 2013 USA and 2015 Ireland curricula (Kaya & Erduran, 2016a).

Kaya and Erduran (2016b) investigated Turkish science and chemistry curricula were published in 2013. The purpose of the study is to determine which categories of the RFN are focused on the 2013 science and chemistry curricula. By analyzing the data sources, the researchers took into consideration of the categories’ definitions that were defined by Erduran and Dagher (2014a). The results of the curriculum analysis were presented for each category of the RFN. It was found that the social context of science does not present adequately in the 2013 science and chemistry curricula. Additionally, the results show that the categories of aims and values, and social organizations and interactions only take place in the science curriculum. On the other hand, scientific methods, scientific practices, scientific knowledge, social certification and dissemination, and social values categories are mentioned in both of the curricula (Kaya & Erduran, 2016b).

To sum up, the analyses of Turkish science curricula in terms of previous and recently developed NOS perspectives exist in the literature. While some of the studies included several curriculum analyses, some of them included only one curriculum analysis. Approximately similar results with the international NOS curriculum analyses were found. This means that most of the NOS aspects do not take part in the Turkish science curricula. Furthermore, based on the RFN studies' findings, social-institutional categories were emphasized less than cognitive-epistemic categories in most of the studies. On the other hand, like in the international curriculum analysis, in some of these studies, only some sections of the curriculum were analyzed. Even though the recently developed Turkish science curriculum was analyzed before, the study's theoretical framework was not depend on the RFN.

2.5. Teachers' Views of Nature of Science (NOS)

A written curriculum may not be sufficient in order to achieve expected results (Doganay & Sarı, 2008). To achieve expected results, one of the important elements is teachers (Ozturk, 2012). Because each teacher implements the curriculum differently, teachers' views of NOS are important as far as the curriculum. When teachers have competent NOS understandings, they can transfer their knowledge to the students in some extend. Herman *et al.* (2013) found that NOS might be implemented in classrooms with the help of an intensive teacher education program. Nawaz and Akbar (2019) supported this idea by emphasizing the importance of professional development in curricular practices. In the literature, there are some studies that reveal the teachers' NOS views or the effects of training on teachers' NOS understandings. In some studies, there is a comparison among different demographic information of teachers in the context of the NOS. Moreover, the studies that were conducted with teachers are in accord with the studies that were conducted with pre-service teachers to a great extent.

Mıhladız and Dogan (2014) conducted a study with eight teachers to learn NOS views of science teachers. Additionally, they examined science teachers' views of NOS in science teaching. The data were obtained from individual interviews that include a semi-structured questionnaire. The findings showed that there are some naïve views in the context of the scientific methods, types of scientific knowledge, and social aspects of science. Furthermore, Mıhladız and Dogan (2014) stated that science teachers' views were limited while explaining NOS in science teaching.

Vázquez-Alonso *et al.* (2013)'s research is one of the studies that investigated the NOS thinking of science teachers. 494 prospective and 280 in-service Spanish science teachers attended this research and "Opinions about Science, Technology and Society Questionnaire" was used as an instrument. The results stated that science teachers' NOS conceptions are adequate with some issues. These issues are about the teachers' misconceptions and inappropriate conceptions in the topic of the NOS. To deal with the inadequate NOS conceptions, some studies provided professional development programs and evaluate their effects on teachers.

Kartal *et al.* (2018) conducted a study that evaluates the effectiveness of Continuing Professional Development (NOS-CPD) program on 18 science teachers' NOS views. The program lasted a yearlong and data was collected through pre and post interviews. The results of the study showed that the NOS-CPD has an impact on the teachers' NOS views positively (Kartal *et al.*, 2018). Moreover, it was found that while naive NOS views of the teachers decrease, informed NOS views of teachers increase.

Buxner (2014) also assessed the findings of a development program like in Kartal *et al.* (2018)'s study. In this study, 43 science teachers' NOS and scientific inquiry understandings were researched as a result of science research programs. Many data collection techniques such as open-ended surveys, long-term surveys, interviews, focus groups, observations, and field notes were used. The findings of the study stated that research experiences in the program lead teachers to improve NOS and scientific inquiry on a small scale.

Irez *et al.* (2018)'s research purpose is to determine science teachers' competence while identifying NOS aspects in educational critical scenarios (ECS). ECS are related to the socio-scientific issues such as global warming, dinosaurs, and so on. The data was collected from 15 science teachers through interviews and an open-ended questionnaire after a professional development program (Irez *et al.*, 2018). The findings stated that after the professional development program, science teachers have informed conceptions in most of the NOS aspects. On the other hand, most participants did not transfer them into the ECS. As a result, it was emphasized that the informed NOS conceptions are not enough to apply them in the implementation of teaching.

Similar finding was also emphasized in Lederman (1999)'s study. According to the Lederman (1999)'s study, teachers' NOS understandings do not affect the implementation of NOS in classrooms. The study was conducted with five biology teachers by using different data collection tools such as interviews, questionnaires, classroom observations, and lesson plans. The results showed that NOS views of teachers are parallel with the education reforms. However, they do not include the NOS into their instructions as a purpose.

Another study investigated the relationship between science teachers' NOS understandings and classroom instructions (Kurup, 2014). In the study, there were two groups who one of them attended an explicit professional development program about NOS. Data collection sources were a questionnaire, semi-structured interview, and classroom observation. In the study, some domains of the science such as scientific method, scientific knowledge, social aspects of science, and so on were taken into consideration. The findings represented that the explicit professional development program affected the teachers' NOS understandings and classroom instructions positively in some NOS categories. However, there were still challenges that teachers experienced in the domain of "the socio-cultural aspects of science, theories and laws, and the role of imagination in developing scientific knowledge" (Kurup, 2014).

Saif (2016) conducted a study that aims to find science teachers' NOS views. 83 science teachers were selected randomly from Najran, Saudi Arabia. A questionnaire that includes five aspects of NOS such as scientific theories and models, role of scientists, scientific knowledge, scientific method, and scientific laws was presented to the teachers. According to the informed conception results of the teachers, no significant difference between male and female science teachers was found (Saif, 2016). As a general, it was determined that Saudis science teachers have uninformed conceptions about NOS.

Karaman (2017) used a questionnaire including five sub-sections to learn the teachers' views on NOS as well. Moreover, the theoretical framework of the research was based on the consensus view of NOS. He investigated the effects of some demographic variables such as teaching discipline, gender, education level, teaching experience, and work location on teachers' NOS views. 647 elementary, science, and physics teachers attended to this survey research in the context of an astronomy science camp project. The results of the study showed that gender and education level do not cause a significant difference in teachers' scores. On the other hand, in some sub-sections of the questionnaire, significant differences were found based on the teaching discipline, teaching experience, and work location (Karaman, 2017).

Another study that investigated the NOS beliefs of the teachers in the context of the different variables was conducted by Altundas (2021). The researcher focused on the teachers who visited the science center. "Nature of Science Beliefs Scale" was used to collect data from the 304 teachers by taking into consideration the gender, school type, experience, and branches. The only statistically significant difference was seen in the sub-factor of the "scientific knowledge change" based on the gender variable in contrast to Saif (2016) and Karaman (2017)'s studies. This difference was in favor of the female teachers.

Aliyazicioglu (2012) investigated the NOS perceptions of teachers from different branches. Because the study was conducted in an Anatolian high school, it is a case study. The number of the participants is nine teachers and the data collection instruments are interviews and classroom observations. In the observations, it was expected that participants design and apply one-hour experimental lecture. Some of the themes that were used in the data analysis are the definition of science, aim of science, interaction between science and society, scientific methods, and tentativeness of science (Aliyazicioglu, 2012). Philosophy teacher has a highest NOS perception. On the other hand, science related branch teachers such as biology, physics, and chemistry teachers' perceptions are in the low rank even though the science is a main topic.

Azninda *et al.* (2021) investigated science and non-science teachers' NOS views by using the RFN framework. Both the RFN Questionnaire and interviews were used as instruments in the study. According to the quantitative data results came from the RFN Questionnaire, there is no significant difference between the science and non-science teachers based on the NOS views (Azninda *et al.*, 2021). On the other hand, in the interviews, it was realized that social-institutional categories of science were not explained well even though there are high scores in these categories (Azninda *et al.*, 2021).

Aksoz (2019) also carried out a mixed study like in Azninda *et al.* (2021)'s study. The sample of the study is the teachers from science, physics, chemistry, and biology departments. The purpose of the study was limited to the teachers' aims and values and social-institutional aspects of the RFN understanding (Aksoz, 2019). The research design of the study is the explanatory sequential mixed method including the questionnaire and interview (Aksoz, 2019). The quantitative data results showed that the teachers' scores on questionnaire did not have a significant difference based on the variables that are teaching branches, teaching experiences, school types, and educational status (Aksoz, 2019). Moreover, qualitative results represented that teachers had insufficient NOS understanding (Aksoz, 2019).

Demirel (2021) conducted a study about science teachers' NOS views in the context of the RFN. In addition to the NOS views, science teachers' views about the integration of the RFN into the science lectures, and the place of the RFN into the science curriculum were focused in the study. Semi-structured interviews were conducted with 13 science teachers working in public and private schools, and were analyzed by using the qualitative content analysis. General codes and sub-codes about all categories of the RFN were created. The general codes are "meaning, curricular emphasis, and integration to instruction". Findings of the study indicated that graduate student teachers have more informed views about NOS (Demirel, 2021). Moreover, it was found that while teachers who were dealt with NOS add the NOS into their instructions, teachers who have limited NOS understanding did not make connections with the curriculum.

As a result, there are a lot of studies that analyzed the teachers' NOS views. However, the number of studies conducted with teachers from the RFN perspective is rare. As a data collection instrument, questionnaires and interviews were usually used. Moreover, in most of these studies, the relationship between teachers' NOS views and their demographic information such as branch, experience, school type, educational status, gender, work location, and so on were looked at. Mostly, no difference was found between demographic information in the context of the teachers' views on NOS. On the other hand, as a general, it was indicated that the teachers' NOS views are limited in the studies. Therefore, there are some studies that assessed the teacher development programs effectiveness in the context of the NOS. In these studies, it was usually found that the teachers' NOS views increase after the programs.

2.6. Teachers' Curriculum Implementations

In the previous sections, the studies about NOS in science curricula and teachers' views of NOS were presented. In addition to these, this section presents how curriculum and teachers are related to each other by mentioning curriculum implementation studies in the literature. The Oxford dictionary (n.d.) defines implementation as "the act of making something that has been officially decided start to happen or be used". In an educational context, the person who acts based on the officially decided curriculum is the teachers and they design their teaching and learning activities based on the curriculum. In other words, teachers are the implementors of the curriculum in the classrooms. Therefore, teachers are one of the critical components of curriculum implementation (Tokgoz, 2013). Student, subject, and social context can be shown as the other critical components (Tokgoz, 2013). According to Roehrig *et al.* (2007)'s study, school support is another factor affecting curriculum implementation in addition to the teaching beliefs. This means that these components can affect how the curriculum is implemented in classrooms. Moreover, the literature showed that the difference between theory and practice appears in the usage of the national curriculum (Tokgoz, 2013). This can be a result of teachers' practices of the curriculum.

Kaya *et al.* (2012) conducted a phenomenological study that examines curriculum implementations of teachers. The participants of this study are seven chemistry teachers working in Turkey. A semi-structured interview including 17 questions were used as an instrument and data was analyzed by content analysis. The findings of the study showed that the teachers see the curriculum as the main document when they plan lessons because it includes lesson subjects and timeline (Kaya *et al.*, 2012). Additionally, it was found in the study that some internal factors such as teaching experience affect the implementation of the curriculum. It was concluded that when the teachers have more teaching experience, they implement the curriculum efficiently.

Another phenomenological study was conducted by Tokgoz (2013). She aimed to examine teachers' perceptions and implementations of the social studies curriculum. First of all, semi-structured interviews were conducted with 30 teachers. Then, 10 teachers were observed in the classroom and were interviewed. In conclusion, it was found that the teachers' perceptions and understandings of the curriculum affect the implementation of the curriculum (Tokgoz, 2013). Additionally, three types of teacher groups such as "curriculum followers", "curriculum extenders", and "curriculum adapters" were generated based on the transformation the curriculum.

Roehrig *et al.* (2007)'s study focused on the effects of teachers' beliefs on the implementation of the reform-based curriculum. The data were collected from 27 chemistry teachers by conducting interviews and making observations. As similar to Tokgoz (2013)'s study, three teacher groups which are "inquiry teachers", "mechanistic teachers", and "traditional teachers" were generated in order to categorize the beliefs of the teachers. It was found that teaching beliefs of teachers shape the implementation of the curriculum. For instance, mechanistic teachers applied all aspects of the curriculum as they are to their lessons, while inquiry teachers applied the curriculum by giving importance to the interaction. Quantitative results of the study also showed a statistically significant relationship between teaching beliefs and curricular implementations (Roehrig *et al.*, 2007).

Atila and Sozbilir (2016) investigated how teachers practice constructivist principles in the science and technology curriculum. Participants of the study are seven science and technology teachers. The implementations of the teachers were observed by using an observation form. The findings showed that the curriculum is practiced different from the written curriculum. Furthermore, it was indicated that only 1,7 % of the behaviors were depicted by the teachers as an example of constructivist principles (Atila & Sozbilir, 2016).

Karabacak and Kurum-Yapıcıoglu (2020) carried out a study that examines the accordance between the written and implemented English curriculum. Many data collection tools such as questionnaires, semi-structured interviews, and diaries were used in the study. The participants of the study were English teachers working in primary schools. Descriptive statistics and inductive analyses were conducted for quantitative and qualitative data, respectively. The findings showed that even though the teachers practiced content and objectives in the curriculum, they did not practice all teaching-learning processes and evaluations (Karabacak & Kurum-Yapıcıoglu, 2020). Teachers' competencies in the profession were seen as one of the reasons for discrepancies in the implementation.

To sum up, the studies in the literature show that the curriculum implementation changes from teacher to teacher. In the studies, interviews and observations were mostly used to be able to collect data. According to the findings of these studies, teachers' experiences, beliefs, professional competencies, and curriculum perceptions and understandings are some of the reasons that affect their curriculum implementations. Teachers' engagement with the curriculum might be improved by starting to determine their views of the curriculum. Thus, concrete steps can be taken for curriculum implementation.

2.7. Summary of the Literature Review

The NOS is a highly popular topic in science education. Therefore, there are many studies that investigated the NOS from different perspectives in the literature. Some of the perspectives are "Consensus View" (Abd-El-Khalick & Lederman, 2000), "Whole Science" (Allchin, 2011), "Features of Science" (Matthews, 2012), and "Family Resemblance Approach (FRA) to NOS" (Irzik & Nola, 2011). Moreover, there is a recent perspective that is the "Reconceptualized Family Resemblance Approach to Nature of Science (RFN)" that was adapted from FRA to NOS by Erduran and Dagher (2014a) and named by Kaya and Erduran (2016a). The RFN has 11 categories including the cognitive-epistemic and social-institutional aspects of the science. It is a holistic framework and so it causes a comprehensive understanding for science. Moreover, the RFN is a pedagogical framework that can be applied in classroom. Therefore, it makes students' NOS understanding easier.

Studies related to the RFN were mostly conducted with middle school students, high school students, pre-service teachers, and textbooks. On the other hand, curriculum analysis and teachers' views in the context of the RFN are in limited number. However, the inclusion of the RFN in the science curriculum is significant for students' NOS understandings. Moreover, because teachers apply the curriculum in the classroom, their views on NOS should be considered as well (Azninda *et al.*, 2021). According to the conducted international and national curriculum analysis studies' findings, it was usually found that the inclusion of NOS is rarely or implicitly mentioned (e.g. Ferreira & Morais, 2013; Izci, 2017; Yeh *et al.*, 2019). Moreover, while analyzing several science curricula, only some sections were taken into consideration in the literature. On the other hand, in this research, whole sections in the recent Turkish science curriculum were analyzed based on the whole RFN categories. Additionally, another purpose of this study is to explore science teachers' views on the RFN and science curriculum. Because the study investigated NOS from two sides which are curriculum and teachers, it is separated from the literature. In the literature, it was usually found that the teachers have narrow NOS views (e.g. Aksoz, 2019; Azninda *et al.*, 2021). Moreover, to cope with this problem, it was conducted studies that evaluated the teachers' NOS views after the teachers attended professional development programs. Most of the time, these programs were found effective for the teachers' NOS views according to the studies in the literature (e.g. Buxner, 2014; Kartal *et al.*, 2018). There are also studies that show the importance of the teachers in the curriculum implementations. According to these studies, curriculum implementations change from the written curriculum because of the teachers (e.g. Tokgoz, 2013; Roehrig *et al.*, 2007).

3. METHODOLOGY

In this chapter, the methodology of the study is explained in detail. The methodology chapter consists of the research design, research context, data sources, instrumentation, data analysis, trustworthiness, and permission and ethical considerations.

3.1. Research Design

A qualitative research design was used in the study in order to explore the inclusion of the RFN in the science curriculum. Furthermore, a qualitative research design helped to explore science teachers' RFN and curriculum views. To support the interview data, the RFN Questionnaire results of the science teachers were also taken into consideration. Respectively, research design techniques that are used for the curriculum and teachers are explained below.

The qualitative research design was preferred both for the curriculum and participant sections of the study. Qualitative research includes gathering, analyzing, and interpreting non-numerical data in order to understand a phenomenon in a deep way (Mills & Gay, 2016). One of the sections of the study aims to investigate the inclusion of the RFN in the Turkish science curriculum, while the other section aims to investigate science teachers' views about the RFN and curriculum through interviews. Because the curriculum document and interview data are non-numerical data, qualitative research is the design of the study.

Content analysis as one of the qualitative research design techniques was used to analyze the inclusion of the RFN in the Turkish science curriculum (MEB, 2018a). According to Krippendorff (2004), the meaning of content analysis is to make inferences from written materials by paying attention to replicability and validation of inferences. Additionally, the thematic analysis was used as another qualitative research design technique while analyzing the interviews of science teachers. According to Braun and Clarke (2006), thematic analysis is "a method for identifying, analyzing, and reporting patterns (themes) within data" (p.6) and it helps to organize and explain large data minimally. In addition to the qualitative research design, the RFN levels of science teachers were measured through the RFN Questionnaire to support the data coming from the science teachers' interviews.

3.2. Research Context

The Turkish science curriculum was analyzed in the scope of the RFN. Moreover, the interviews were conducted with the science teachers working in Turkey to understand their RFN and curriculum views. Additionally, the RFN Questionnaire was given to the science teachers in order to measure their RFN understanding levels. In the section of the research context, first of all, information about the Turkish national education system is provided to learn the research context well. Then, the places of the science-related courses and teachers who have a science-related teaching branch in the Turkish education system are mentioned. Lastly, the structure of the Turkish science curriculum which was developed by the National Ministry of Education in 2018 was explained generally.

The structure of the Turkish national education system consists of formal and non-formal education (OGM, 2015). While formal education involves preschool, primary school, middle school, high school, and higher education, non-formal education involves the educational activities along with the formal education or out of formal education (OGM, 2015). Additionally, formal education is given regularly to individuals at a specific age under the roof of a school with the help of national curricula. In Turkey, the 4+4+4 education system was accepted in 2012 (OGM, 2015). After this system, compulsory education begins at six years old and lasts 12 years consisting of four years for primary school, four years for middle school, and four years for high school (OGM, 2015). The context of the study consists of formal education of some parts of primary school (Grades 3-4) and the entire middle school (Grades 5-8). Students at these levels are between the ages of eight and 13 because science education starts to be given in the 3rd grade.

Turkey's national education system includes science-related courses during compulsory education from primary school to high school. Science-related courses are science, physics, chemistry, and biology. For the different science-related courses and levels, there are specialized teachers who were graduated from the education faculty of universities. Moreover, persons who were graduated from faculty of arts and sciences can work as a teacher after taking a pedagogical formation. The science courses start to be given to the 3rd and 4th graders in primary school by primary school teachers. In between 5th and 8th grades, science education is given to the students with specialized science teachers. Then, in high school from the grade of 9th to 12th, science course is separated into physics, chemistry, and biology and these lectures are given by the teachers who were graduated from the related departments of education or arts and sciences faculties. The given weekly science courses are three and four hours respectively for primary school and middle school students. In addition to the compulsory science courses, it can be given two hours of science courses in the context of science application courses.

The Turkish national science curriculum is the common document for primary and middle schools. The total page number of the science curriculum (MEB, 2018a) is 58. The science curriculum includes some common and different sections for primary and middle school levels. "National Ministry of Education curricula, aims of the curricula, perspectives of the curricula, assessment and evaluation approach in the curricula, individual development and the curricula, result, special aims of the curriculum, field-specific skills in the curriculum, practices of science, engineering, and entrepreneurship in the curriculum, and matters to be considered in the application of the curriculum" are the common sections for both levels (MEB, 2018a). The section of National Ministry of Education curricula emphasizes the philosophy of the science-related curricula. According to this section, the curricula were prepared by considering the personal differences and aiming to gain values and skills (MEB, 2018a). Moreover, the curriculum gives importance to grow up individuals who are a problem-solver, critical thinker, entrepreneur, knowledge builder and knowledge user, and so on (MEB, 2018a). In addition to the common sections in the curriculum, the section of "structure of the curriculum" differentiates in each grade. The context of the study consists of the recent Turkish science curriculum and science teachers in Turkey. More information was given in the data sources section including the Turkish science curriculum and participants.

3.3. Data Sources

In the study, there are two data sources that are curriculum which is the recently developed Turkish science curriculum (MEB, 2018a) and participants who are science teachers working in Turkish middle schools. Respectively, the Turkish science curriculum and participants were explained as data sources of the study.

3.3.1. Turkish Science Curriculum

The main data source of the study is the science curriculum (MEB, 2018a) of the Turkish National Ministry of Education. It was selected purposively because the science curriculum was renewed in 2018 and this is the current version that has been using in schools from that time. The Turkish science curriculum was prepared for the primary school (Grades 3, 4) and middle school (Grades 5, 6, 7, 8) students (MEB, 2018a). It consists of 58 pages. As already mentioned, the science curriculum has some common sections for the primary school and middle school. These sections are "National Ministry of Education curricula, aims of the curricula, perspectives of the curricula, assessment and evaluation approach in the curricula, individual development and the curricula, the result, special aims of the curriculum, field-specific skills in the curriculum, practices of science, engineering, and entrepreneurship in the curriculum, and matters to be considered in the application of the curriculum" as seen in Figure 3.1 (MEB, 2018a). The names of the sections were taken directly from the curriculum itself.

In the National Ministry of Education curricula section, it is mentioned that the science-related curricula focus on the metacognitive abilities, meaningful and permanent learning, relationship with previous learning, multidisciplinary, and daily life relations by integrating them in the scope of the values, skills, and competencies (MEB, 2018a). The section about the aims of the curricula identifies the different aims for the end of preschool, primary school, middle school, and high school (MEB, 2018a). The main aim of the science curriculum is to grow up scientifically literate individuals and it has 10 other special aims. The science curriculum also includes the field specific skills that are scientific process skills, life skills, engineering and design skills. Moreover, the science curriculum gives importance to the practices in science, engineering and entrepreneurship. In this way, students are expected to follow the stages of problem finding, product developing, and product presenting (MEB, 2018a). Another section mentions the matters that should be considered during the implementation of the science curriculum by giving teacher-student roles, and adopted strategies and methods (MEB, 2018a).

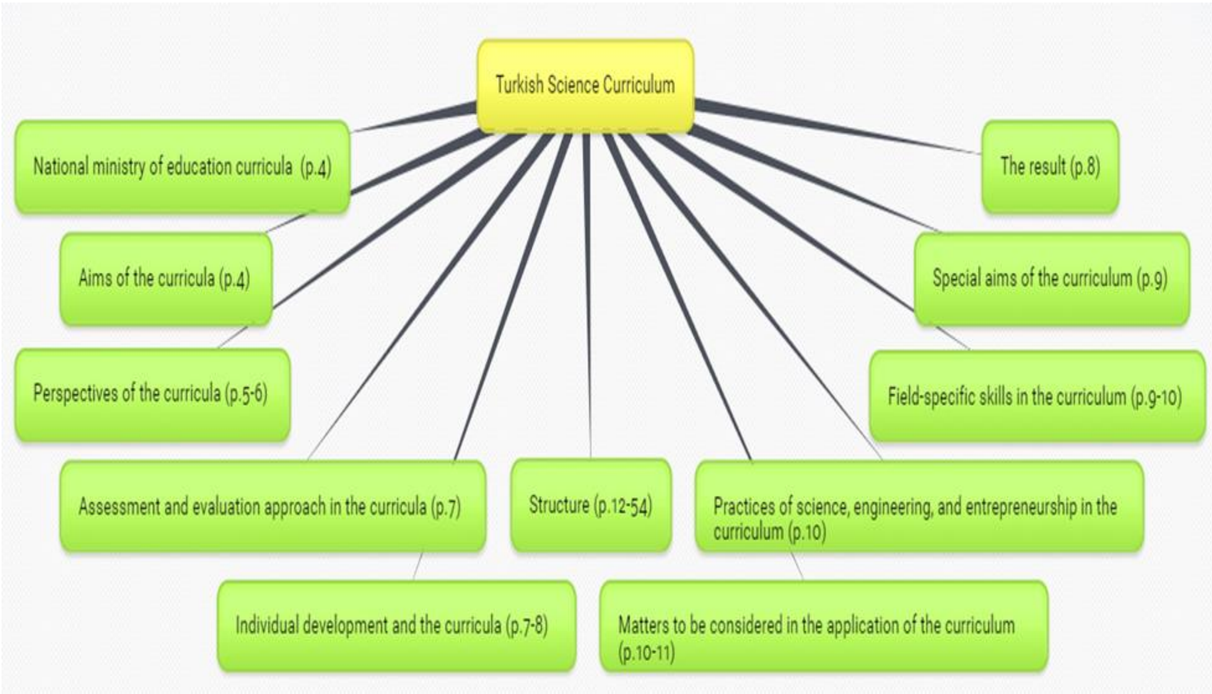

Figure 3.1. The Sections of the Turkish Science Curriculum.

The differentiation about the science curriculum takes place in the structure section of the curriculum. In the structure section, there are three sub-sections. One of them is the tables for grades 3-8 that show units, subjects, objective numbers, foreseen lecture hours, and percentages (MEB, 2018a). The second sub-section includes the numbers and sizes of the 3rd, 4th, 5th, 6th, 7th, and 8th grade science textbooks (MEB, 2018a). In the last sub-section, the tables are explained by giving related-objectives and concepts in addition to units, subjects, and foreseen lecture hours (MEB, 2018a). In each grade from 3 to 8, the same subjects are shown with the same order but different contents. In other words, the science curriculum is a spiral curriculum. The subjects that take place in the science curriculum are "Earth and Universe", "Living Things and Life", "Physical Events", and

“Matters and Its Nature” (MEB, 2018a). In the science curriculum, the subjects of “Earth and Universe” and “Matters and Its Nature” take place one time in each grade levels. On the other hand, the subject of “Living Things and Life” takes place two times while the subject of “Physical Events” takes place three times in each grade levels. Additionally, the objectives have a noticeable place in the Turkish science curriculum. Therefore, some numbers were assigned them. Figure 3.2 shows how the objectives were named by giving an example from the curriculum. The first letter means the first letter of science course in Turkish. Also, grade level, unit number, subject number, and objective number are indicated, respectively. The total objective numbers are 36, 46, 36, 59, 67, and 61 respectively for 3rd, 4th, 5th, 6th, 7th, and 8th grade levels. This means that the science curriculum includes more objectives in 7th grade level.

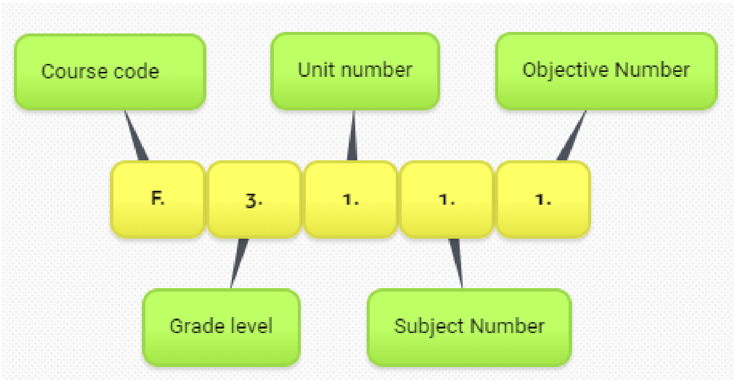

Figure 3.2. The Depiction of an Objective in the Turkish Science Curriculum.

3.3.2. Participants

The sample of the study is teachers who are working in Turkey. 10 science teachers were selected for the study. Science teachers were selected with purposeful sampling that is one of the non-random sampling strategies. According to Mills and Gay (2016), non-random sampling is a kind of sample selection that is determined without a chance or probability from a population. On the other hand, purposeful sampling is a sample selection type that is thought to show the population’s characteristics. In purposeful sampling, the sample is selected in terms of the determined criteria (Mills & Gay, 2016). For the study, one of the criteria is to become a science teacher. Additionally, variety in gender, teaching experience, school type, and educational status were considered while determining the participants of the study. Five science teachers from Public Schools (PU) and five science teachers from Private Schools (PRI) were selected. In this way, it was aimed that the science teachers in the study represent to the large spectrum.

Table 3.1 shows the demographic information of the science teachers who are participants of the study. In the study, six teachers are female while four teachers are male. Teaching experiences of teachers are in between one year to 21 years. Moreover, the educational statuses of teachers are bachelor's degree (f=6), graduate student (f=2), master's degree (non-thesis) (f=1), and doctoral student (f=1). The data was collected from the science teachers between November 2021 and January 2022. Firstly, the permission from Bogazici University Research Ethics Sub-Committee (see Appendix A) was taken to guarantee the ethical considerations. Additionally, before gathering data from the science teachers who were selected purposively, an informed consent form had taken (see Appendix B) from them. With the help of the informed consent form, science teachers had information about the aims of the study and their rights in the study.

Table 3.1. Demographic information of the participants.

Participant Number	**Gender**	**Teaching Experience**	**School Type**	**Educational Status**
1	Female	2	Private	Graduate Student
2	Female	2	Public	Bachelor's Degree
3	Female	13	Private	Bachelor's Degree
4	Female	1	Public	Bachelor's Degree
5	Female	5	Private	Master's Degree (Non-thesis)
6	Male	2	Public	Graduate Student
7	Female	12	Public	Doctoral Student
8	Male	7	Private	Bachelor's Degree
9	Male	7	Private	Bachelor's Degree
10	Male	21	Public	Bachelor's Degree

3.4. Instrumentation

In the study, the Turkish science curriculum was investigated through content analysis. Moreover, some data collection tools such as the semi-structured interview protocol and the RFN Questionnaire were used in the study to collect data from the science teachers. While the semi-structured interview protocol provides to understand science teachers' RFN and curriculum views, the RFN Questionnaire provides to determine the level of the science teachers' RFN understandings. Respectively, the semi-structured interview protocol and the RFN Questionnaire are explained.

3.4.1. Semi-Structured Interview Protocol

Interviews with the science teachers were conducted to explore their views of the RFN and the inclusion of the RFN in the science curriculum. According to Creswell (2012), in the interviews, participants are asked open-ended questions. Therefore, 29 open-ended questions that include the demographic information, nature of science, and curriculum issues were prepared for the interviews of the science teachers (see Appendix C). These questions were asked through an online platform that is Zoom Meeting. With the help of the online platform, science teachers became more accessible. Also, it is thought that the teachers feel more comfortable while they are explaining their views. After their permission, the answers of the science teachers were recorded by the researcher via using an audio recorder. Then the researcher transcribed all audio recordings.

The numbers of the questions are 4, 14, and 11 for the questions of demographic information, nature of science, and curriculum issues respectively. Some of the questions were adapted from the previous RFN related studies (e.g. Akgun, 2018; Cilekrenkli, 2019; Kaya *et al.*, 2019) to the study. As demographic information, the teaching discipline, teaching experience, type of school, and educational status were asked to the participants. Moreover, the questions about the nature of science specifically consist of all RFN categories while the questions of the curriculum issues consist of the inclusion of the RFN on the science curriculum and implementations. Cognitive-epistemic and social-institutional aspects of science questions take place in the interview questions related to nature of science. Some of the interview questions are; "What do scientific practices mean? What examples of scientific practices can you give?", "What do you think social organizations and interactions mean? Where can scientific knowledge be produced?", "Are there any emphases on the nature of science in the science curriculum? If any, which components were highlighted?". The last questions about the curriculum include five quotations from the Turkish science curriculum. It was considered to select that the quotations show different RFN categories. Thus, three of the quotations were selected from the main purposes of the science curriculum while two of the quotations were selected from the objectives. The first quotation that is "In the process of discovering nature and understanding the relationship between human-environment, adopting scientific process skills and scientific research approach and producing solutions to the problems encountered in these fields" (MEB, 2018a, p.9) refers to the AV, SV, and SP categories. The second quotation that is "To help understand how scientific knowledge is created by scientists, the processes that this knowledge goes through and how it is used in new research" (MEB, 2018a, p.9) refers to SK and M categories. The third quotation that is "To ensure the adoption of universal moral values, national and cultural values and scientific ethical principles" (MEB, 2018a, p.9) refers to SV and SE categories. The fourth quotation that is "Presents the observation results of a plant's life cycle. It is expected to monitor the development of a plant for a certain period of time and to record the observation results" (MEB, 2018a, p.18) refers to SP, SCD, and PA categories. The last quotation that is "Discusses the importance of conscious and efficient use of electrical energy in terms of family and national economy. The studies carried out by official institutions and non-governmental organizations in our country on energy efficiency and the things to be done in terms of electrical energy use are stated" (MEB, 2018a, p.54) refers to SP and SOI categories.

The interviews lasted between 40-60 minutes according to the participants' pace. For the content validation of the questions in the interview, two pilot studies were conducted with science teachers before the main interviews. After the pilot studies, there was no need to make changes in the questions because the questions were understandable for the pilot participants. These studies became beneficial for the researcher to make practice before the actual interviews. Additionally, an expert opinion was taken for the validation of questions in the interview.

3.4.2. RFN Questionnaire

The RFN Questionnaire (see Appendix D) was used in the study in order to support the data coming from the science teachers' interviews. Therefore, the RFN Questionnaire was presented to the science teachers after the interviews through a social media tool that is WhatsApp. This is because of protecting the teachers from any bias and impact about the study. Otherwise, teachers' comments in the interviews can be affected from the items in the questionnaire. The RFN Questionnaire is used to find the NOS levels of science teachers. The RFN Questionnaire was developed by Kaya *et al.* (2019) and consists of 70 items. Table 3.2 shows the categories of the items, item examples, number of items dedicated to the RFN category and positive and negative items reference in the questionnaire. The questionnaire includes all categories of the RFN that are the cognitive-epistemic and social-institutional aspects of science. The numbers of items are 7, 13, 9, 9, 16, and 16 respectively for the categories of aims and values, scientific practices, scientific methods, scientific knowledge, social-institutional aspects, and educational applications. The items in the questionnaire are in the type of 5 points Likert scale. This means that the participants answered the items by selecting "1= Totally disagree, 2= Disagree, 3= Not sure, 4= Agree, 5= Totally agree". Some of the items in the RFN Questionnaire have negative meaning. Therefore, these were coded as the reverse of the positive items. This means that the coding was "5= Totally disagree, 4= Disagree, 3= Not sure, 2= Agree, 1= Totally agree". Therefore, while the lowest score is 70, the highest score is 350 for the questionnaire results. While the positive item numbers are 49, the negative item numbers are 21 in the questionnaire. Some of the positive items are; "The diversity of scientists solving a problem means less biased results" and "Each branch of science has a different nature". On the other hand, some negative items are; "All scientific disciplines such as physics, biology and chemistry use the same scientific method" and "Scientific knowledge does not change". The items in the questionnaire were transferred to the Google forms and the link of the questionnaire was shared with the science teachers via WhatsApp. Answering the RFN Questionnaire lasts approximately 20 minutes. Kaya *et al.* (2019) found the Cronbach alpha as 0.8 for the reliability of the questionnaire. Moreover, two experts in science education field controlled the items' suitability and gave feedback (Kaya *et al.*, 2019). Then, the changes in the items were made in order to provide the content validation of the questionnaire (Kaya *et al.*, 2019).

Table 3.2. Positive and negative items in the RFN Questionnaire. Source: [Kaya et al., 2019, p. 30].

Category	**Example**	**Number of items dedicated to RFN category**	**Item reference in questionnaire**	
			Positive	**Negative**
Aims and values	*The diversity of scientists solving a problem means less biased results (Positive item)*	7	2, 20, 40, 51, 69	46, 56
Scientific practices	*Each branch of science has a different nature (Positive item)*	13	4, 5, 15, 19, 23, 33, 38, 57, 61, 63	26, 52, 64
Scientific methods	*All scientific disciplines such as physics, biology and chemistry use the same scientific method (Negative item)*	9	11, 22, 24, 28	8, 25, 37, 49, 60
Scientific knowledge	*Scientific knowledge does not change (Negative item)*	9	10, 30, 44, 50, 54	3, 16, 43, 66
Social – institutional aspects	*Scientists should respect the environment (Positive item)*	16	7, 9, 14, 32, 34, 41, 45, 48, 53, 58, 67, 70	13, 18, 36, 39
Educational applications	*Teaching science should specify that laws are certain and unchangeable. (Negative item)*	16	1, 6, 12, 17, 21, 27, 29, 31, 42, 55, 59, 62, 65	35, 47, 68

3.5. Data Analysis

In the data analysis section, respectively, the analysis steps of the Turkish science curriculum, science teachers' interviews and the RFN Questionnaire are explained.

3.5.1. Analysis of the Turkish Science Curriculum

The recent Turkish science curriculum (MEB, 2018a) was analyzed by using the content analysis. In the analysis of the study, the components of the content analysis (Figure 3.3) that were provided by Krippendorff (2004) were benefitted. There are six components of the content analysis that are "unitizing, sampling, recording/coding, reducing, inferring, and narrating" (Krippendorff, 2004). To follow these components linearly is not necessary if the repetition in some steps of the analysis is needed. This means that iterative loops can be followed while conducting the content analysis (Krippendorff, 2004).

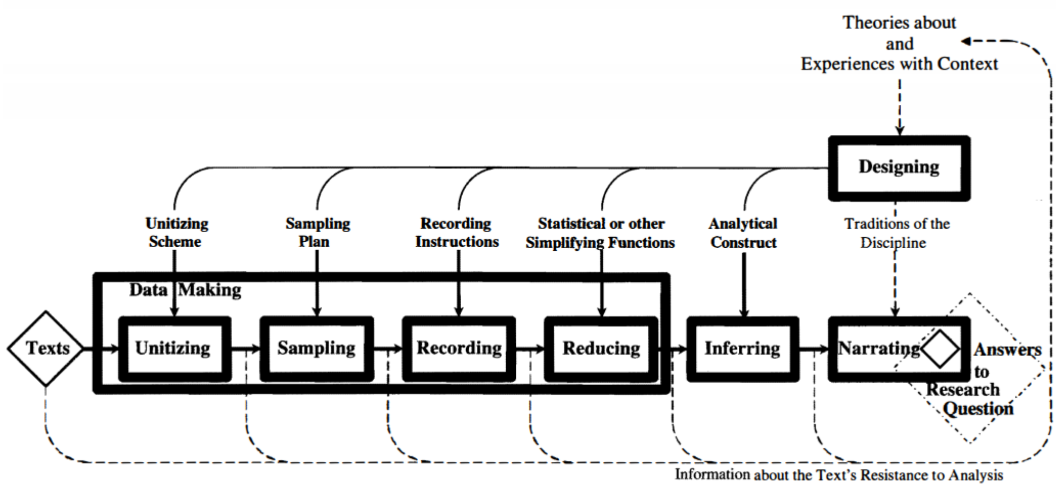

Figure 3.3. Components of Content Analysis. Source: [Krippendorff, 2004, p. 86].

According to Krippendorff (2004), the first step which is unitizing means the systematic separation of text into sections based on the interest of the analysis. In the unitizing phase of the analysis, whole science curriculum was separated into the sections because all of the sections are related to the analysis. There are 11 sections of the science curriculum that are about the "National Ministry of Education, aims, perspectives, assessment and evaluation approach, individual development, result, special aims, field-specific skills, practices of science, engineering, and entrepreneurship, matters to be considered in the application, and structure". The second step that is sampling narrow downs the interested context into controllable subsets representing possible all units in order to economize (Krippendorff, 2004). For the text analysis, from words to the whole publication can be read as different levels (Krippendorff, 2004). Thirdly, Krippendorff (2004) defined the recording/coding step as bridge between unitized texts and reader. In this study, the sections of the science curriculum were coded based on the RFN framework. While analyzing science curriculum, keywords of the RFN categories that were obtained from Kaya and Erduran (2016a)'s study were used. Additionally, new keywords were generated as a result of the science curriculum analysis. Table 3.3 represents 11 categories of the RFN, their descriptions, and keywords. For example, aims and values category of the RFN was defined as "the key cognitive and epistemic objectives of science, such as accuracy and objectivity" and its keywords were exemplified as "aim, value, goal, accuracy, and objectivity" in Table 3.3. In the science curriculum analysis, the frequency of each keyword was counted in order to show how the curriculum includes the RFN. During the curriculum analysis process, MAXQDA 2020 that is qualitative data analysis software was used in order to count the number of codes and categorize them easily. Because the data that comes from the curriculum is large, the codes were reduced to the categories of the RFN. According to Krippendorff (2004), data reduction provides the productive representation. The first four components were named as data making because computable data from the original texts were generated (Krippendorff, 2004). The fifth step is the abductive inference that makes the content analysis different from other inquiry approaches (Krippendorff, 2004). Because the main phenomenon is the RFN in the study, it was made inferences based on this phenomenon. At the end of the content analysis, it was reached the answer of the research question. With the step of the narrating, the findings of the study might be meaningful for readers. Additionally, narrating requires to be presented the significance of the findings to the literature (Krippendorff, 2004).

Table 3.3. Keywords used to trace RFN categories in curricula. Source: [Kaya & Erduran, 2016a, 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	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
Social certification and dissemination	The social mechanisms through which scientists review, evaluate, and validate scientific knowledge for instance through peer review systems of journals	Peer-review, validate, evaluate, certification, dissemination, collaboration
Scientific ethos	The norms that scientists employ in their work as well as in interaction with colleagues	Scientific norms, ethics, bias, being sceptical, caution against bias

Table 3.3. Keywords used to trace RFN categories in curricula (cont.).

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

To provide inter-rater reliability in the curriculum data analysis, the researcher and two science teachers who are studying Ph.D. at Mathematics and Science Education assessed the selected data individually. The coders' research topics in their master degrees were about the RFN. Therefore, it can be said that they have informed RFN views. In order to make curriculum data analysis easier for coders, Table 3.3 was provided them. 2 documents that include special aims of the curriculum and structure section in the Turkish science curriculum were shared with the coders. The section of the special aims of the curriculum was selected as an inter-rater reliability data because it has diversity and many codes in the context of the RFN. Additionally, in the structure section of the curriculum, the researcher paid attention to select the inter-rater reliability data from different grade levels that are from 3rd to 8th and different subjects that are "Earth and Universe", "Living Things and Life", "Physical Events", and "Matters and Its Nature". Also, it was paid attention that data have various codes. Analysis results were compared with the coders to have a consensus in the selected data. While the agreement between one of the coders and researcher is 93.15%, the agreement between other coder and researcher is 86.96%.

3.5.2. Analysis of the Teachers' Interviews and RFN Questionnaire

When analyzing the semi-structured interview protocols, thematic analysis was used as qualitative research approach. According to Braun and Clarke (2006), there are six phases that help the researchers to use during the thematic analysis. These phases are "familiarizing yourself with your data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report" (Braun & Clarke, 2006). To be familiar with the data, the verbal data in the audio recordings were transcribed into the written format. Then, the written documents were uploaded to MAXQDA 2020 that is qualitative data analysis software in order to organize data easily. From the written documents of each participant, the codes were generated by considering the RFN framework. After that, the codes were collected under the candidate themes and these were reviewed. At the end, themes that give the exact meanings were produced. The literature was benefited from while coding the interview data. To provide inter-rater reliability in the data analysis, the researcher and two coders generated codes in the selected data. Then, the analysis results were compared. The selected data belongs to one of the pilot studies. While the agreement between one of the coders and researcher is 96.09%, the agreement between other coder and researcher is 93.60%.

In addition to the interview analysis, the RFN Questionnaire results of the science teachers were analyzed. In the analysis of the RFN Questionnaire, descriptive statistics were conducted. An Excel document was used for the descriptive analysis of the data. With the help of the descriptive statistics, the scores of the science teachers were calculated as the total score of the RFN Questionnaire and each score of the categories of the RFN Questionnaire. In the RFN Questionnaire, there are positive and negative items related to the 5 RFN categories and educational applications. Therefore, positive items were coded as

1, 2, 3, 4, and 5 for the "Totally Disagree", "Disagree", "Not Sure", "Agree" and "Totally Agree" alternatives respectively. On the other hand, negative items were coded the reverse of the positive items. This means that negative items were coded as 5, 4, 3, 2, and 1 for the "Totally Disagree", "Disagree", "Not Sure", "Agree" and "Totally Agree" alternatives respectively. Because the questionnaire has 70 items with 5 point Likert scale, the lowest score and highest questionnaire score of the science teachers are calculated respectively as 70 and 350. Additionally, the lowest scores for the aims and values, scientific practices, scientific methods, scientific knowledge, social-institutional aspects, and educational applications categories are 7, 13, 9, 9, 16, and 16 while the highest scores for the aims and values, scientific practices, scientific methods, scientific knowledge, social-institutional aspects, and educational applications categories are 35, 65, 45, 45, 80, and 80.

3.6. Trustworthiness

It is important to indicate that the findings of the study are accurate or credible (Creswell, 2012). Accuracy or credibility of a qualitative study was named as trustworthiness by some qualitative researchers (Creswell, 2012). In this section, trustworthiness of the study is presented. Guba and Lincoln (1982) proposed some strategies for trustworthiness of a study that are "credibility", "transferability", "dependability", and "confirmability". These terms refer to the terms that are used in quantitative research respectively for "internal validity", "external validity", "reliability", and "objectivity".

Credibility means that the researcher realizes the complexities in the study and copes with the difficulties that are not clarify easily (Mills & Gay, 2016). To achieve credibility of the findings, it should be considered to what extent the categories represent data (Graneheim & Lundman 2004). In other words, it shows that relevant data are not excluded or irrelevant data are not included (Graneheim & Lundman 2004). The quotations that were taken from both the Turkish science curriculum and interviews of the science teachers were presented in this study in order to prove credibility of the study. According to Graneheim and Lundman (2004), seeking agreement is one of the ways of the credibility. Thus, in the present study, agreement rates between 2 coders who have a master's thesis on the topic of RFN and the researcher were found for both specific data in the curriculum and interviews. The agreement rates were found at the appropriate level and so the researcher continued to code all data individually.

Transferability is another strategy for providing the trustworthiness of the study. It means that "the extent to which the findings can be transferred to other settings or groups" (Polit & Hungler, 1999, p.435). To achieving transferability, the explanations of context, participants, data collection, and data analysis should be presented in detail (Graneheim & Lundman 2004). In this study, all of these processes were mentioned respectively. For example, it was talked about the sample selection type that is purposeful sampling and the demographic information of the participants related with the study. The context of the study is limited to Turkey, so aspects of Turkey were presented.

Dependability is the third strategy that is used for trustworthiness of a qualitative study. According to Guba and Lincoln (1982), dependability refers that the repeatability of a study in a different context and time under the same conditions. In other words, it is necessary to have a stability of data (Mills & Gay, 2016). For providing dependability of the study, the codifications of the data were repeated at different times by the researcher and corrections were made in the codes. Moreover, the data that were selected from the curriculum and interviews were shared with two Ph.D. students to make codification. An agreement for coding was reached. This situation may prove the dependability of the study with an audit trail.

Lastly, objectivity in quantitative research refers to the confirmability of qualitative research. To cope with the confirmability issues, triangulation was proposed in Guba and Lincoln (1982)'s study. The triangulation is provided by different data sources, instruments, and methods (Mills & Gay, 2016). Using interviews and the questionnaire in the present study to obtain data from the science teachers can be seen as triangulation because different instruments were used to confirm the data coming from the participants.

3.7. Research Permission and Ethical Considerations

The ethical issues were considered during the study. Because the teachers attended to the study as participants, the permission from the Bogazici University Research Ethics Sub-Committee (see Appendix A) was taken. Additionally, an informed consent form (see Appendix B) was given to the participants in order to inform them and take consent from them. In the study, there are no potential risks that can affect the participants' psychological and physiological health. Before the interviews, the informed consent form was given to the science teachers. Thus, participants learned their rights and could ask questions about the study. During the data collection and analysis processes, the participants were coded as numbers. Thus, their identities were kept secret. Moreover, their demographic information and answers to the questions were guaranteed to use only within the context of the study. Demographic information questions including teaching discipline, teaching experience, school type, and educational status were asked in the interview to be able to provide diversity in the sample. The data taken from the participants are accessible only to the researcher and thesis advisor. After the study was finished, all data that is protected in the researcher's personal computer will be demolished. Lastly, in the study, some figures that were taken from books were used by giving references. Also, the permission for figures (see Appendix E) was taken.

4. FINDINGS

In this chapter, the findings of the inclusion of the RFN in the Turkish science curriculum and science teachers' views of the RFN and science curriculum are presented. The findings are shown with the frequency graphs and tables and supported with quotations.

4.1. The Inclusion of the RFN in the Turkish Science Curriculum

This section presents to what extent the RFN is included in the Turkish science curriculum based on the content analysis. In other words, one of the research questions how the Turkish science curriculum includes the RFN was investigated. The codes in the literature that are related to the RFN categories helped to find the representation of the RFN in the curriculum. In addition to the literature, new codes occurred after scanning the curriculum. First of all, a general view of the cognitive-epistemic and social-institutional categories and each categories frequency in the Turkish science curriculum are presented in this section. Then, the frequency of the RFN codes is shown based on the sections of the Turkish science curriculum. Because most of the RFN codes appear in the structure section of the Turkish science curriculum, the inclusion of the each RFN categories in this section is mentioned according to the grade levels. Additionally, the distribution of the RFN categories in other sections of the curriculum is presented. After this general view, each categories of the RFN that are "Aims and Values (AV)", "Methods and Methodological Rules (M)", "Scientific Practices (SP)", "Scientific Knowledge (SK)", "Social Certification and Dissemination (SCD)", "Scientific Ethos (SE)", "Social Values (SV)", "Professional Activities (PA)", "Social Organizations and Interactions (SOI)", "Financial Systems (FS)", and "Political Power Structures (PPS)" is explained in detail. In these sub-sections, generated codes and their frequencies are indicated by supporting with the quotations from the Turkish science curriculum. Moreover, distribution of the frequency of the codes based on the grade levels for each RFN category in the structure section is given with the related quotations.

The number of the total codes that was found in the content analysis is 610. Figure 4.1 shows the distribution of codes' number and percentage for the cognitive-epistemic (f=525; 86%) and social-institutional (f=85; 14%) categories of science in the Turkish science curriculum. Based on this finding, it is seen that the cognitive-epistemic categories of science are emphasized more than the social-institutional categories of science in the curriculum.

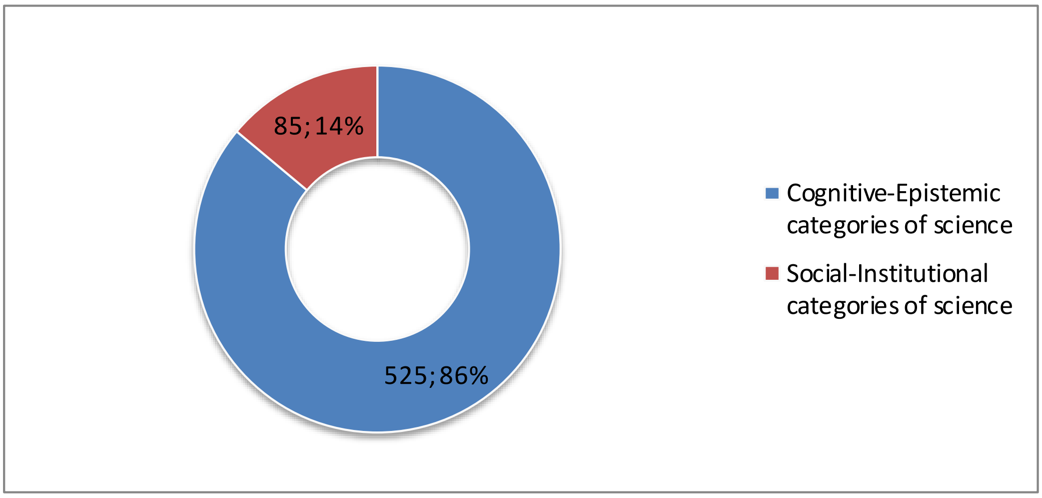

Figure 4.1. Frequency of Codes for the Cognitive-Epistemic and Social-Institutional Categories of Science in the Turkish Science Curriculum.

Cognitive-epistemic categories of science include the categories of AV, M, SP, and SK while social-institutional categories of science include the categories of SCD, SE, SV, PA, SOI, FS, and PPS. Specifically, for each category of the RFN, number of the codes is presented in Figure 4.2. Respectively, the frequency of the codes that were found for AV, M, SP, SK, SCD, SE, SV, PA, SOI, FS, and PPS categories of the RFN are 41, 49, 371, 64, 27, 5, 12, 30, 6, 4, and 1. While the SP category (f=371) is referred most, the PPS category (f=1) is referred least in the Turkish science curriculum. Moreover, total frequency of the codes is 610.

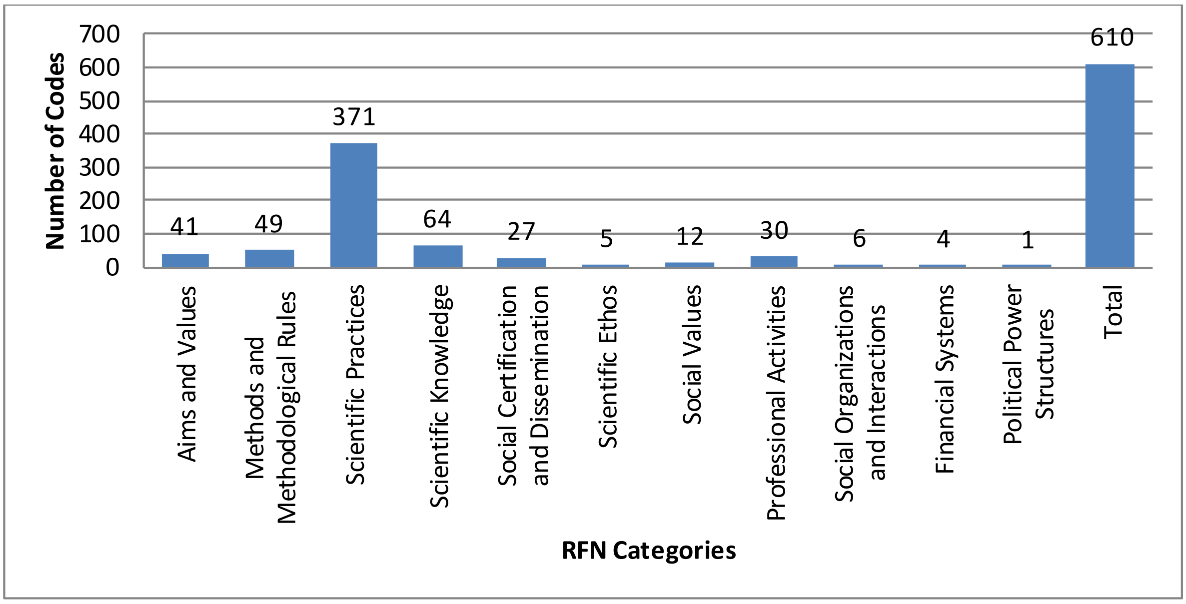

Figure 4.2. Frequency of Codes for the RFN Categories in the Turkish Science Curriculum.

The Turkish science curriculum consists of 11 sections which are "National Ministry of Education curricula, aims, perspectives, assessment and evaluation approach, individual development, result, special aims, field-specific skills, practices of science, engineering, and entrepreneurship, matters to be considered in the application, and structure" (MEB, 2018a). Figure 4.3 shows the frequency of the RFN codes that were found in these sections, respectively, as 8, 3, 21, 0, 2, 0, 19, 17, 26, 45, and 469. Based on this figure, assessment and evaluation approach and result sections of the Turkish science curriculum do not include the RFN codes. On the other hand, the structure of the curriculum section (f=469) has more codes than the other sections. The high page number can have an effect to find the highest codes in the structure section of the curriculum.

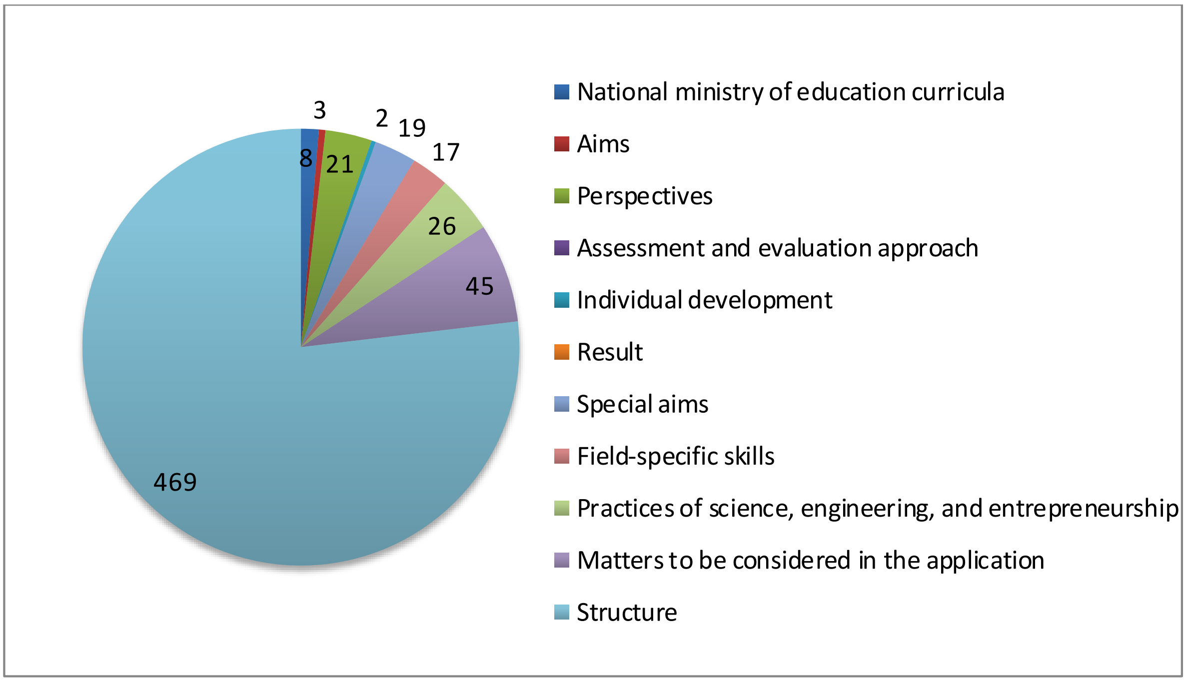

Figure 4.3. Distribution of the Frequency of the RFN Codes in the Sections of the Turkish Science Curriculum.

The details of the structure section of the curriculum are presented in Figures 4.4 and 4.5. While Figure 4.4 shows the distribution of the codes related to cognitive-epistemic categories of the RFN in the structure section, Figure 4.5 shows the distribution of the codes related to social-institutional categories of the RFN in the structure section. Because the structure section of the Turkish science curriculum includes the objectives based on the grade levels, these figures depict the codes of the RFN categories based on the grade levels. In Figure 4.4, it is seen that the SP category is mentioned most while the AV category is mentioned least in the structure section of the curriculum. Additionally, Figure 4.4 depicts the total number of the codes for the cognitive-epistemic RFN categories in the structure section as 43, 47, 72, 80, 94, and 89 for 3rd, 4th, 5th, 6th, 7th, and 8th grade levels. This means that 7th grade includes more codes about cognitive-epistemic aspects of science in the structure section than the other grade levels. The least codes about cognitive-epistemic aspects of science in the structure section were found in the 3rd grade level. In the 3rd grade level, the numbers of the codes are 1, 0, 39, and 3 respectively for AV, M, SP, and SK categories. In the 4th grade level, numbers of the codes are 3, 5, 38, and 1 respectively for AV, M, SP, and SK categories. In the 5th grade level, the numbers of the codes are 2, 9, 58, and 3 respectively for AV, M, SP, and SK categories. In the 6th grade level, the numbers of the codes are 1, 3, 66, and 10 respectively for AV, M, SP, and SK categories. In the 7th grade level, the numbers of the codes are 0, 6, 70, and 18 respectively for AV, M, SP, and SK categories. Lastly, in the 8th grade level, the numbers of the codes are 5, 8, 63, and 13 respectively for AV, M, SP, and SK categories.

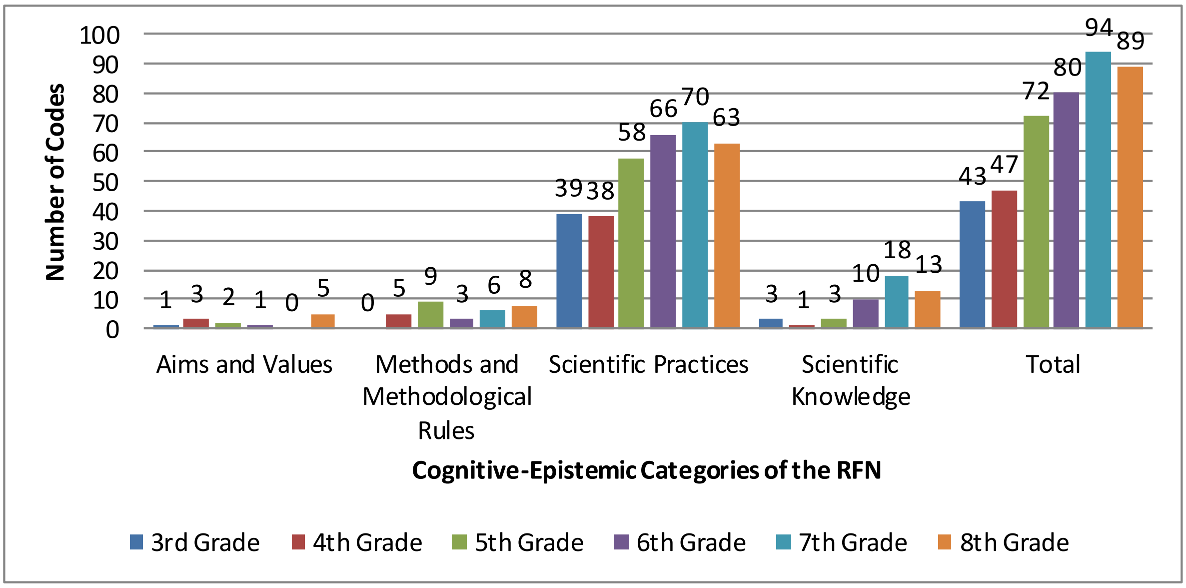

Figure 4.4. Frequency of Codes for Cognitive-Epistemic Categories of the RFN in the Structure Section of the Turkish Science Curriculum Based on Grade Levels.

On the other hand, the inclusion of the social-institutional categories of the RFN is lower than the cognitive-epistemic categories of the RFN in the structure section. As can be seen in Figure 4.5, the structure section does not contain the codes about SE, FS, and PPS. On the other hand, the PA category is mentioned most in this section among the social-institutional categories of the RFN. Moreover, the PA and SCD categories of the RFN take place in all grade levels in contrast to the other social-institutional categories. The total numbers of codes for the social-institutional RFN categories in the structure section are 3, 7, 6, 6, 11 and 11 for 3rd, 4th, 5th, 6th, 7th, and 8th grade levels. This means that 7th and 8th grade levels include more codes about social-institutional aspects of science in the structure section than the other grade levels. The least codes about social-institutional aspects of science in the structure section were found in the 3rd grade level. In the 3rd grade level, the numbers of the codes are 1, 1, 1, and 0 respectively for SCD, SV, PA, and SOI categories. In the 4th grade level, the numbers of the codes are 2, 1, 4, and 0 respectively for SCD, SV, PA, and SOI categories. In the 5th grade level, the numbers of the codes are 2, 0, 4, and 0 respectively for SCD, SV, PA, and SOI categories. In the 6th grade level, the numbers of the codes are 2, 0, 4, and 0 respectively for SCD, SV, PA, and SOI categories. In the 7th grade level, the numbers of the codes are 4, 0, 6, and 1 respectively for SCD, SV, PA, and SOI categories. In the 8th grade level, the numbers of the codes are 2, 0, 4, and 5 respectively for SCD, SV, PA, and SOI categories.

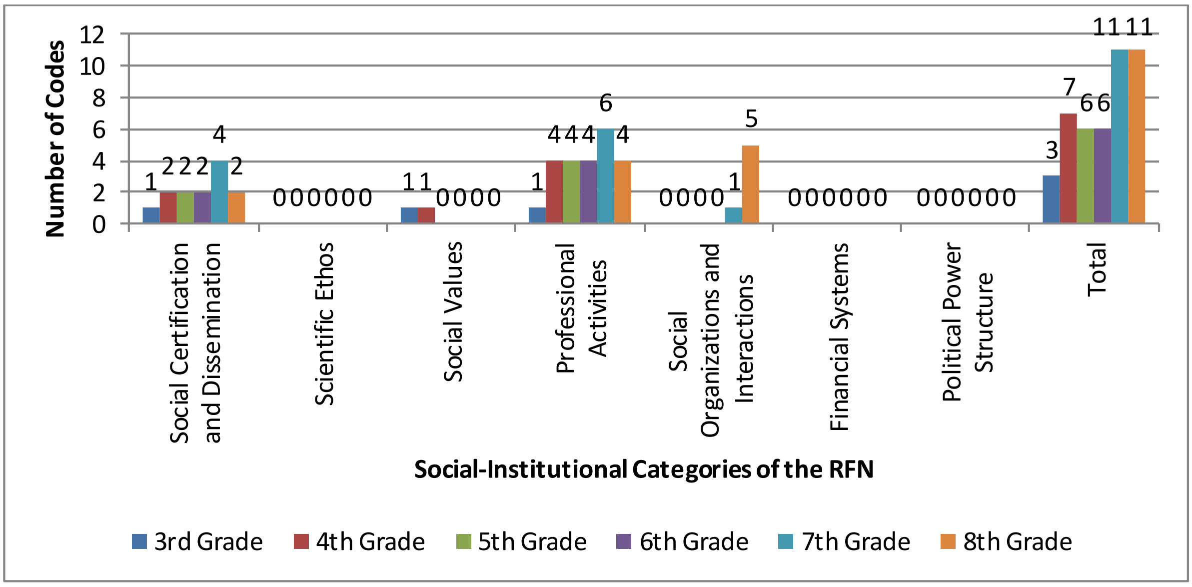

Figure 4.5. Frequency of Codes for Social-Institutional Categories of the RFN in the Structure Section of the Turkish Science Curriculum Based on Grade Levels.

Consequently, a partial progression was found in the total number of the codes among grade levels. This progression was named as partial because 8th grade level is excluded from this progression based on the findings. This means that the progression among grade levels is seen in the total number of the RFN categories from 3rd to 7th grade. In other words, from 3rd to 7th grades, the total number of the codes increased. This progression was also found in the total number of the codes about cognitive-epistemic categories of the RFN from 3rd to 7th grades. However, fluctuations were also found at AV, M, SP, and SK categories of the cognitive-epistemic system based on the grade levels. For example, 5th grade level includes most codes in the M category while 3rd grade level included no codes about the M category. On the other hand, social-institutional categories of the RFN do not represent the same progression. For example, as seen in Figure 4.5, there is equality between 7th and 8th grade levels with the frequency of 11. Other equality takes place in 5th and 6th grade levels with the frequency of 6. The equality between 5th and 6th grade levels stemmed from SCD and PA categories because the same codes repeated in these grade levels. The repeatability of the same codes also is valid from 4th grade level to 8th grade level.

In addition to the structure section of the Turkish science curriculum, the frequency of codes for the RFN categories in the other sections of the curriculum is shown in Table 4.1. The details of this table are given one by one for each category of the RFN in sub-sections. Furthermore, in the sub-sections, the quotations that the codes were formed from take place.

Table 4.1. Frequency of codes for the RFN categories in the each section of the Turkish science curriculum.

Sections of the Turkish Science Curriculum	**Cognitive-Epistemic Categories**				**Social-Institutional Categories**						
	AV	**M**	**SP**	**SK**	**SCD**	**SE**	**SV**	**PA**	**SOI**	**FS**	**PPS**
National Ministry of Education curricula	4	-	-	1	-	-	3	-	-	-	-
Aims	-	-	1	-	-	1	1	-	-	-	-
Perspectives	7	2	-	4	3	2	1	2	-	-	-
Assessment & evaluation approach	-	-	-	-	-	-	-	-	-	-	-
Individual development	-	-	-	2	-	-	-	-	-	-	-
Result	-	-	-	-	-	-	-	-	-	-	-

Table 4.1. Frequency of codes for the RFN categories in the each section of the Turkish science curriculum (cont.).

Special aims	4	2	4	3	-	1	4	-	-	1	-
Field-specific skills	3	3	8	1	2	-	-	-	-	-	-
Practices of science, engineering, entrepreneurship	7	2	7	3	3	-	-	2	-	1	1
Matters to be considered in the application	4	9	17	2	6	1	1	3	-	2	-
Structure	12	31	334	48	13	-	2	23	6	-	-
Total	**41**	**49**	**371**	**64**	**27**	**5**	**12**	**30**	**6**	**4**	**1**

4.1.1. Aims and Values of Science

As seen in Table 4.1, the Aims and Values (AV) category of the RFN was indicated 41 times in the Turkish science curriculum. The sections of the Turkish science curriculum that includes codes about the AV category of the RFN are National Ministry of Education curricula, perspectives, special aims, field-specific skills, practices of science, engineering, and entrepreneurship, matters to be considered in the application, and structure with the frequency of 4, 7, 4, 3, 7, 4, and 12 respectively. The codes that refer to the AV category of the RFN in the Turkish science curriculum are “values” (f=4), “honesty” (f=1), “aim” (1), “meeting needs” (f=4), “developing attitude” (f=1), “arouse curiosity” (f=1), “explanation of nature” (f=1), “explanation of phenomenon” (f=1), “discovery of nature” (f=1), “finding solution for problems” (f=13), “novelty” (f=5), “defining questions” (f=1), “producing evidence-based results” (f=1), “understanding the world” (f=1), “determining problems” (f=1), “arriving scientific knowledge” (f=3), and “discovering scientific knowledge” (f=1). These codes about AV are exemplified below with quotations.

“Aim”, “arriving scientific knowledge”, “explanation of phenomenon”, “discovering scientific knowledge” and “understand the world” codes were referred to in the practices of science, engineering, and entrepreneurship section of the Turkish science curriculum as follows:

> The purpose of science is to create theories by developing logical and systematic explanations for natural phenomena; to explore principles and concepts. By transferring scientific processes to learning environments, it is aimed that students do research to understand the world and understand how scientific knowledge develops by directly participating in the scientific process (MEB, 2018a, p. 10).

In the Turkish science curriculum, the aim of science is mentioned as seen in the quotation. According to this quotation, science aims to reach theories that are one of the scientific knowledge types and to discover laws that are the other scientific knowledge type. Furthermore, the purpose of science is to explain the phenomenon in nature and understand world. “Defining questions”, “producing evidence-based results”, and “explanation of nature” codes were referred to in the perspectives section of the Turkish science curriculum as follows:

> Competence in science refers to the availability of knowledge and the ability and desire to benefit from methodology to explain the natural world in order to define questions and produce evidence-based results (MEB, 2018a, p. 6).

Scientific competency is parallel with the aims of science such as an explanation of the natural world by asking questions and finding evidence-based results to the questions. “Discovery of nature” and “finding solution for problems” codes were referred to in the special aims section of the Turkish science curriculum as follows:

> In the process of discovering nature and understanding the relationship between human and environment, adopting scientific process skills and scientific research approach and producing solutions to the problems encountered in these fields (MEB, 2018a, p. 9).

The curriculum aims that all individuals use scientific process skills and scientific research, and find solutions to the problems during the discovery of nature. This aim is common with the aims of science because scientists discover nature and find solutions to the problems.

The inclusion of the AV category is specifically important for the structure section of the curriculum because it includes the objectives that students are expected to know and apply. Therefore, the frequency of codes for AV in the structure section of the Turkish science curriculum based on grade levels is presented (see Figure 4.6). According to Figure 4.6, from 3rd grade to 8th grade, the frequency of the codes for the AV category of the RFN changes as 1, 3, 2, 1, 0, and 5, respectively. This means that the AV category of the RFN takes place 12 times in the structure section of the curriculum.

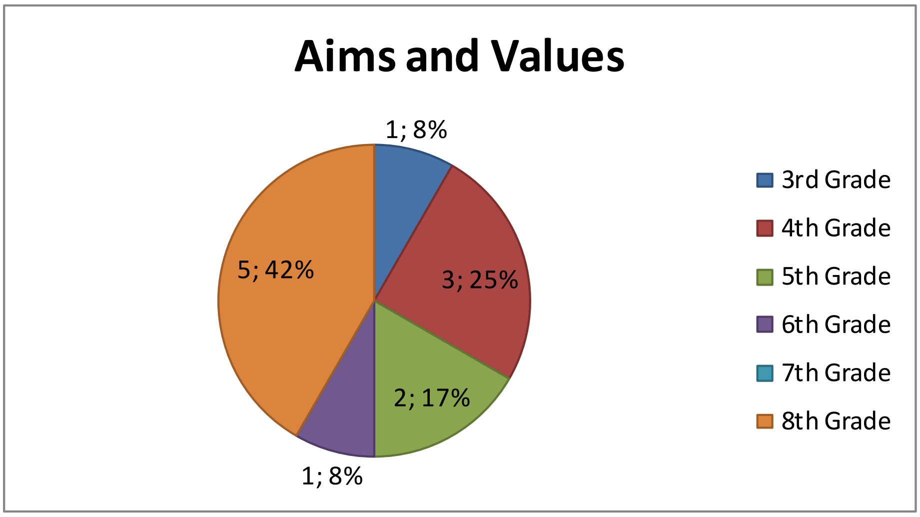

Figure 4.6. Frequency of Codes for Aims and Values Category of the RFN in the Structure Section of the Turkish Science Curriculum Based on Grade Levels.

The code of "novelty" was referred to for 5th grade students in the structure section of the Turkish science curriculum as follows:

> F.5.3.2.3. Generates new ideas to increase or decrease friction in daily life (MEB, 2018a, p. 27).

Students are expected to create new ideas that can make their lives easier on the topic of friction. In this way, it can be also supported students' creative thinking skills. "Determining problems" and "finding solution for problems" codes were referred to for 8th grade students in the structure section of the Turkish science curriculum as follows:

> F.8.6.4.5. Offers solutions by specifying the problems that may be encountered in the future if the resources are not used sparingly (MEB, 2018a, p. 53).

This objective attracts students' attention to sustainable development. Therefore, it expects from students to find problems and propose solutions to these problems on the efficient use of resources.

The inclusion of the AV category of the RFN is limited in the Turkish science curriculum. Moreover, the frequency of the AV codes is few except for the code of "finding solution for problems". In the structure section, 7th grade levels included no codes about the AV category. Additionally, there is no code about the epistemic-cognitive and social aims and values of science such as objectivity, accuracy, critical examination, and decentralizing power in the curriculum.

4.1.2. Methods and Methodological Rules

As seen in Table 4.1, Methods and Methodological Rules (M) category of the RFN was indicated 49 times in the Turkish science curriculum. The sections of the Turkish science curriculum that includes codes about the M category of the RFN are perspectives, special aims, field-specific skills, practices of science, engineering, and entrepreneurship, matters to be considered in the application, and structure with the frequency of 2, 2, 3, 2, 9, and 31 respectively. The codes that refer to the M category of the RFN in the Turkish science curriculum are "process" (f=1), "methodology" (f=2), "method" (f=5), "inquiry" (f=12), "inquiry-based approach" (f=3), "scientific process" (f=5), "hypothesize" (f=1), "manipulation of variables" (f=4), "control of variables" (f=1), "branches of science" (f=1), and "variables" (f=14). These codes about M are exemplified below with quotations.

The code of "inquiry-based approach" was referred to in the matters to be considered in the application section of the Turkish science curriculum as follows:

> The Science Curriculum is based on an inquiry-based learning approach with an interdisciplinary perspective (MEB, 2018a, p. 10).

This sentence shows the importance of inquiry-based learning that consists of research and investigation processes in the science curriculum.

The inclusion of the M category is specifically important for the structure section of the curriculum because it includes the objectives that students are expected to know and apply. Therefore, the frequency of codes for M in the structure section of the Turkish science curriculum based on grade levels is presented (see Figure 4.7). According to Figure 4.7, from 3rd grade to 8th grade, the frequency of codes for the M category of the RFN changes as 0, 5, 9, 3, 6, and 8, respectively. This means that M category of the RFN is included 31 times in the structure section of the curriculum.

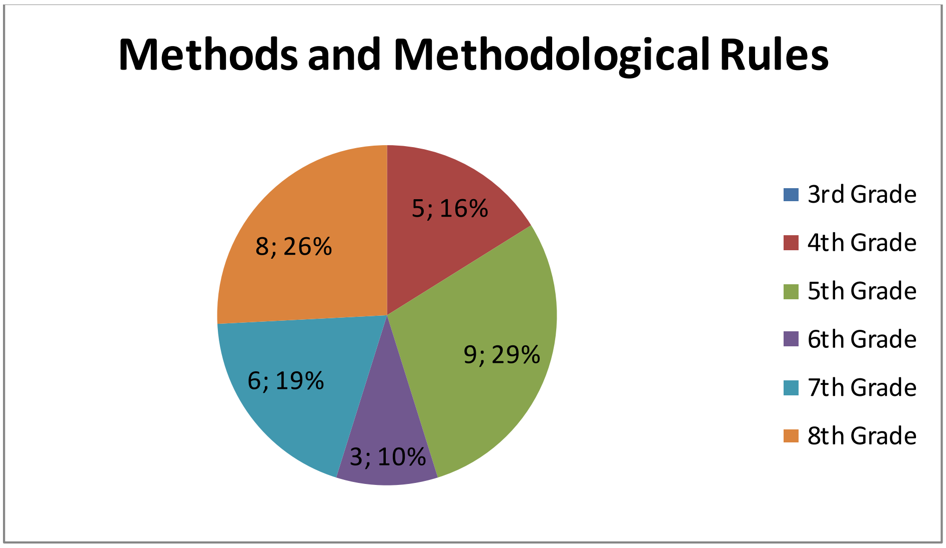

Figure 4.7. Frequency of Codes for Methods and Methodological Rules Category of the RFN in the Structure Section of the Turkish Science Curriculum Based on Grade Levels.

The code of “method” was referred to for the 4th grade students in the structure section of the Turkish science curriculum as follows:

> F.4.4.5.2. Selects the appropriate method among the methods that can be used in the separation of mixtures encountered in daily life. Sieving, filtration and magnetic separation methods are emphasized (MEB, 2018a, p. 22).

This objective gives chance to students to decide which method they can be used to separate mixtures. As examples, teachers can focus on the methods of sieving, filtration and magnetic separation. The code of "manipulation of variables" was referred to for 5th grade students in the structure section of the Turkish science curriculum as follows:

> In this unit, it is aimed that students discover the effects of change on the circuit by changing the number of batteries and lamps in different electrical circuits...(MEB, 2018a, p. 30).

As a general aim of the topic of electrical circuit elements, 5th grade students are expected to manipulate variables that are the number of batteries and lamps and to explore the impact of this manipulation on the circuit. The code of "variables" was referred to for 7th grade students in the structure section of the Turkish science curriculum as follows:

> F.7.6.2.2. Explains the growth and development processes of plants and animals by giving examples. a. An experiment including dependent, independent and controlled variables is provided regarding the factors affecting the germination of the seed. b. Emphasize on an example of a flowering plant (MEB, 2018a, p. 45).

This objective assumes that students know the meaning of the dependent, independent and controlled variables. Therefore, it expects from them to make an experiment about the germination of the seed that includes these variables. The code of "process" was referred to for 8th grade students in the structure section of the Turkish science curriculum as follows:

> F.8.4.1.1. Explains how groups and periods are formed in the periodic system. The need for the periodic system and the creation process of the periodic system are emphasized without going into detail (MEB, 2018a, p. 50).

To create the periodic system includes some progression that was required the usage of scientific methods. Even though it is expected to mention from this progression superficially, this objective might help students to understand the formation of periodic system.

The emphasis of the M category of the RFN can be increased by focusing on different scientific methods such as non-hypothesis testing and non-manipulative description. Furthermore, hypothesis testing can be mentioned explicitly in the curriculum. Instead of these emphases, the codes of "variables" and "manipulation of variables" that show manipulative description were found. Additionally, the structure section has a big piece in the M category when comparing other sections of the curriculum. However, 3rd grade level did not include any codes about M.

4.1.3. Scientific Practices

As seen in Table 4.1, Scientific Practices (SP) category of the RFN was indicated 371 times in the Turkish science curriculum. The sections of the Turkish science curriculum that includes codes about the SP category of the RFN are aims, special aims, field-specific skills, practices of science, engineering, and entrepreneurship, matters to be considered in the application, and structure with the frequency of 1, 4, 8, 7, 17, and 334 respectively. The codes that refer to the SP category of the RFN in the Turkish science curriculum are "explanation" (f=78), "scientific research" (f=2), "research" (f=10), "science process skills" (f=3), "observation" (f=31), "classification" (f=29), "measurement" (f=7), "experimentation" (f=30), "data" (f=2), "research data" (f=5), "data recording" (f=2), "data collection" (f=4), "using data" (f=3), "modeling" (f=12), "connection among concepts" (f=17), "comparison" (f=22), "argumentation" (f=4), "discussion" (f=31), "make inference" (f=11), "prediction" (f=13), "testing" (f=6), "giving examples" (f=23), "reasoning" (f=13), "putting scientific ideas" (f=1), and "representation" (f=12). These codes about SP are exemplified below with quotations.

The code of "reasoning" was referred to in the special aims section of the Turkish science curriculum as follows:

> Developing reasoning ability, scientific thinking habits and decision-making skills by using socio-scientific issues (MEB, 2018a, p. 9).

In this quotation, the socio-scientific issues are seen as topics that might support reasoning ability of students. This means that the curriculum gives importance to the reasonable thinking especially in socio-scientific issues. "Argumentation" and "discussion" codes were referred to in the matters to be considered in the application section of the Turkish science curriculum as follows:

> Environments should be provided where students can discuss the benefit-harm relationship regarding scientific phenomena so that they can freely express their ideas, support their thoughts

with different justifications, and develop opposing arguments to refute the claims of their friends (MEB, 2018a, p. 11).

This statement was given as one of the adopted strategies and methods under the heading of the matters to be considered in the application section. Based on the sentence, teachers are expected to create a learning environment that provides argumentation in science lectures. In this context, argumentation might be provided by the creation or refute of claims based on evidence. Moreover, this quote emphasizes to make an argumentation-based learning with discussion.

The inclusion of the SP category is specifically important for the structure section of the curriculum because it includes the objectives that students are expected to know and apply. Therefore, the frequency of SP in the structure section of the Turkish science curriculum based on grade levels is presented (see Figure 4.8). According to Figure 4.8, from 3rd grade to 8th grade, the frequency of the codes for the SP category of the RFN changes as 39, 38, 58, 66, 70, and 63, respectively. This means that SP category of the RFN takes place 334 times in the structure section of the curriculum.

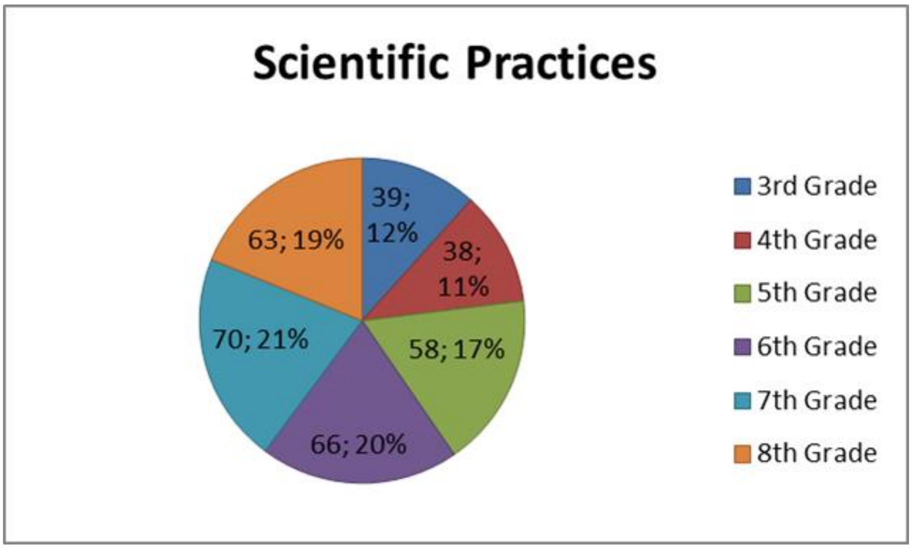

Figure 4.8. Frequency of Codes for Scientific Practices Category of the RFN in the Structure Section of the Turkish Science Curriculum Based on Grade Levels.

"Giving examples" and "explanation" codes were referred to for 3rd grade students in the structure section of the Turkish science curriculum as follows:

> F.3.7.1.1. Explains the importance of electricity in daily life by giving examples of electric tools and equipment from its immediate surroundings (MEB, 2018a, p. 19).

This objective expects from students to be able to make explanation about the electricity and give examples to the electrical tools. "Experimentation" and "comparison" codes were referred to for 6th grade students in the structure section of the Turkish science curriculum as follows:

> F.6.4.1.2. Compares the changes in the space between the particles of the substance and the mobility of the particles depending on the change of state by making experiment (MEB, 2018a, p. 34).

This objective gives importance to conduct an experiment to understand the change of state. Also, it is wanted to make a comparison among the state of solid, liquid, and gas based on the experiment. "Observation" and "make inference" codes were referred to for 7th grade students in the structure section of the Turkish science curriculum as follows:

> F.7.7.1.2. Makes inferences by observing the brightness of the bulbs on the circuit when they are connected in series and parallel (MEB, 2018a, p. 46).

According to this objective, students are expected to observe the types of circuits and make inferences based on their observations like scientists.

In conclusion, the SP category was included more than the other categories in the Turkish science curriculum. Also, most of the codes of SP took place in the structure section of the curriculum. All grade levels include SP and the frequency of the SP codes increases from lower grade levels to higher grade levels. The mostly referred codes about the SP category are "explanation", "observation", "discussion", "experimentation", and "classification". This means that there is imbalance among the number of the codes of SP.

4.1.4. Scientific Knowledge

As seen in Table 4.1, Scientific Knowledge (SK) category of the RFN was indicated 64 times in the Turkish science curriculum. The sections of the Turkish science curriculum that includes codes about the SK category of the RFN are National Ministry of Education curricula, perspectives, individual development, special aims, field-specific skills, practices of science, engineering, and entrepreneurship, matters to be considered in the application, and structure with the frequency of 1, 4, 2, 3, 1, 3, 2, and 48 respectively. The codes that refer to the SK category of the RFN in the Turkish science curriculum are "theory" (f=1), "theory as a kind of scientific knowledge" (f=1), "knowledge" (f=26), "formulation of scientific knowledge" (f=3), "model" (f=14), "law" (f=3), "law as a scientific knowledge" (f=1), "scientific knowledge" (f=7), "cumulative development of scientific knowledge" (f=2), "development of scientific knowledge" (f=3), and "tentativeness" (f=3). These codes about SK are exemplified below with quotations.

"Formulation of scientific knowledge" and "cumulative development of scientific knowledge" codes were referred to in the special aims section of the Turkish science curriculum as follows:

> To help understand how scientific knowledge is created by scientists, the processes that this knowledge goes through and how it is used in new research (MEB, 2018a, p. 9).

While the creation of knowledge in the quotation refers to the code of formulation of scientific knowledge, to use knowledge in new research in the quotation refers to the code of cumulative development of scientific knowledge. "Cumulative development of scientific knowledge" and "scientific knowledge" codes were referred to in the individual development section of the Turkish science curriculum as follows:

> In the process of curriculum development, a harmonic approach has been adopted that takes into account the harmony between all components, taking into account the existing scientific knowledge and experience on the multi-dimensional developmental characteristics of human beings (MEB, 2018a, p.7).

This sentence is not related to the teaching of scientific knowledge. It indicated that the scientific knowledge about the developmental characteristics of people paid attention when the curriculum was developed. This means that curriculum development requires systematic progress that the scientific knowledge has importance.

The inclusion of the SK category is specifically important for the structure section of the curriculum because it includes the objectives that students are expected to know and apply. Therefore, the frequency of codes for SK in the structure section of the Turkish science curriculum based on grade levels is presented (see Figure 4.9). According to Figure 4.9, from 3rd grade to 8th grade, the frequency of codes for the SK category of the RFN changes as 3, 1, 3, 10, 18, and 13, respectively. This means that SK category of the RFN takes place 48 times in the structure section of the curriculum.

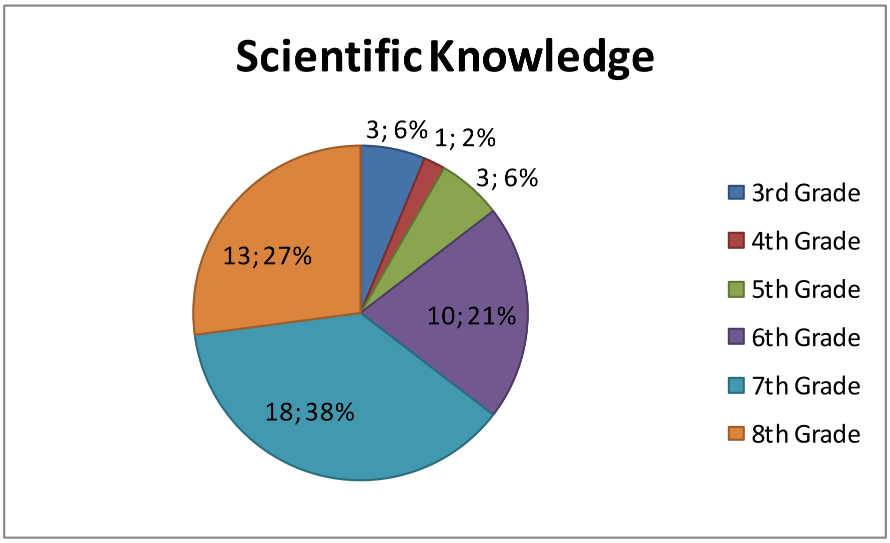

Figure 4.9. Frequency of Codes for Scientific Knowledge Category of the RFN in the Structure Section of the Turkish Science Curriculum Based on Grade Levels.

"Development of scientific knowledge", "tentativeness", "scientific knowledge", and "theory as a kind of scientific knowledge" codes were referred to for 7th grade students in the structure section of the Turkish science curriculum as follows:

> F.7.4.1.2. Questions how the ideas about the concept of atom have changed from past to present. a. Details about atomic theories are not given. b. It is emphasized that scientific knowledge can change over time. c. General information about theory, one of the types of scientific knowledge, is given (MEB, 2018a, p. 42).

This objective emphasizes that scientific knowledge can be developed and changed by giving the example of atom. Also, it suggests teachers to explain the theory as one of the scientific knowledge types. The code of "model" was referred to for 8th grade students in the structure section of the Turkish science curriculum as follows:

> F.8.2.1.2. Shows the structure of DNA on the model (MEB, 2018a, p. 48).

Model is a type of scientific knowledge. Even though this quotation does not focus on that, it directs students to investigate the model of the DNA. "Law" and "law as a scientific knowledge" codes were referred to for 8rd grade students in the structure section of the Turkish science curriculum as follows:

> F.8.3.1.3. Gives examples to the applications of pressure properties of solids, liquids and gases in daily life and technology. a. Examples of applications of Pascal's principle related to fluid pressure are given. b. Principles are emphasized as a type of scientific knowledge (MEB, 2018a, p.49).

The law of Pascal was took part in the curriculum as Pascal's principle. To make understandable for students this principle, teachers are expected to give some applications of it. Moreover, teacher should give this principle as one of the scientific knowledge based on the objective.

After the SP category of the RFN, the SK category has the second highest codes in the Turkish science curriculum. Moreover, in the high grade levels that are 6th, 7th, and 8th grades, the number of the codes is high when comparing other grade levels in the curriculum. The law and theory were referred to as scientific knowledge in the curriculum with few references. However, even though using models or making models has a significant place in the curriculum, models was not indicated as scientific knowledge. Additionally, the interactions among the kinds of scientific knowledge were not mentioned.

4.1.5. Social Certification and Dissemination

As seen in Table 4.1, Social Certification and Dissemination (SCD) category of the RFN was indicated 27 times in the Turkish science curriculum. The sections of the Turkish science curriculum that includes codes about the SCD category of the RFN are perspectives, field-specific skills, practices of science, engineering, and entrepreneurship, matters to be considered in the application, and structure with the frequency of 3, 2, 3, 6, and 13 respectively. The codes that refer to the SCD category of the RFN in the Turkish science curriculum are “evaluation” (f=2), “cooperation” (f=6), and “presentation” (f=19). These codes about SCD are exemplified below with quotations. The code of “presentation” is common with the code of “presentation” that was mentioned in the PA category of the RFN.

“Evaluation” and “presentation” codes were referred to in the perspectives section of the Turkish science curriculum as follows:

> Digital competence: It covers the safe and critical use of information and communication technologies for business, daily life and communication. This competence is supported by basic skills such as accessing information and using computers to evaluate, store, produce, present and exchange information, as well as participating in common networks and communicating via the internet (MEB, 2018a, p. 6).

Digital competence was indicated in the curriculum as one of the important competencies that students should be capable of. The sentence emphasizes the evaluation and presentation of knowledge that implies the SCD category of science by using computers. The code of “cooperation” was referred to in the matters to be considered in the application section of the Turkish science curriculum as follows:

> Students engage in effective communication and cooperation while researching and questioning information with their peers (MEB, 2018a, p. 11).

This sentence supports that students study with their peers within cooperation during the investigation of knowledge. Therefore, students can behave like a scientist who cooperates with other scientists to improve the knowledge.

The inclusion of the SCD category is specifically important for the structure section of the curriculum because it includes the objectives that students are expected to know and apply. Therefore, the frequency of codes for SCD in the structure section of the Turkish science curriculum based on grade levels is presented (see Figure 4.10). According to Figure 4.10, from 3rd grade to 8th grade, the frequency of codes for the SCD category of the

RFN changes as 1, 2, 2, 2, 4, and 2, respectively. This means that the SCD category of the RFN takes place 13 times in the structure section of the curriculum.

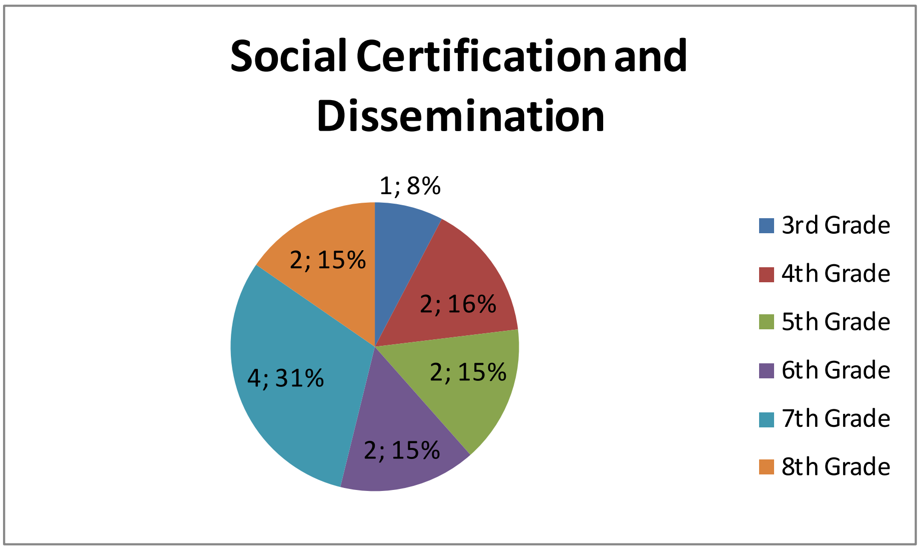

Figure 4.10. Frequency of Codes for Social Certification and Dissemination Category of the RFN in the Structure Section of the Turkish Science Curriculum Based on Grade Levels.

The code of "presentation" was referred to for 3rd grade students in the structure section of the Turkish science curriculum as follows:

F.3.6.1.2. Presents the observation results of a plant's life cycle (MEB, 2018a, p. 18).

This objective expects students to present the results of their observations like in the dissemination of the scientific research in a conference. Because the code of "presentation" is common for both SCD and PA category of the RFN, it can be found other quotations in the findings of the PA section.

To sum up, the Turkish science curriculum does not contain enough codes about the SCD category of the RFN. Although the number of the codes is seen as the second highest code in the social-institutional aspects of science, most of them are repetitive codes. The certification process of knowledge and the ways of knowledge dissemination that scientists use were not mentioned.

4.1.6. Scientific Ethos

As seen in Table 4.1, Scientific Ethos (SE) category of the RFN was indicated 5 times in the Turkish science curriculum. The sections of the Turkish science curriculum that includes codes about the SE category of the RFN are aims, perspectives, special aims, and matters to be considered in the application with the frequency of 1, 2, 1, and 1 respectively. The codes that refer to the SE category of the RFN in the Turkish science curriculum are “ethics” (f=2), “ethical values” (f=1), and “scientific ethics norms” (f=2).

The code of “scientific ethics norms” was referred to in the special aims section of the Turkish science curriculum as follows:

> To ensure the adoption of universal moral values, national and cultural values and scientific ethical principles (MEB, 2018a, p. 9).

The emphasis of scientific ethical principles is directly related with the scientific ethics norms that scientists should comply. However, the examples of these norms are not given in the science curriculum. Another quotation that the code of “scientific ethics norms” is included is presented in the SV category of the RFN below because the related codes are in the same sentence.

As a result, the representation of SE is rare in the Turkish science curriculum and the structure section did not contain any codes about this category. Therefore, SE might not be taught to students well.

4.1.7. Social Values

As seen in Table 4.1, Social Values (SV) category of the RFN was indicated 12 times in the Turkish science curriculum. The sections of the Turkish science curriculum that includes the codes about the SV category of the RFN are National Ministry of Education curricula, aims, perspectives, special aims, matters to be considered in the application, and structure with the frequency of 3, 1, 1, 4, 1, and 2 respectively. The codes that refer to the SV category of the RFN in the Turkish science curriculum are “society” (f=5), “culture” (f=1), “cultural” (f=1), “respect” (f=1), “respect for the environment” (f=1), “universal moral values” (f=2), and “interaction between human and environment” (f=1).

The code of “society” was referred to in the special aims section of the Turkish science curriculum as follows:

> To realize the mutual interaction between individual, environment and society; to develop awareness of sustainable development regarding society, economy and natural resources (MEB, 2018a, p. 9).

This quotation implies that one of the aims of the science curriculum is to teach the relationship among individual, environment and society. In this way, students can aware of the effect of the society. The code of “universal moral values” was referred to in the matters to be considered in the application section of the Turkish science curriculum as follows:

> The teacher encourages students to develop the spirit and sense of research and scientific way of thinking, and ensures that universal moral values, national and cultural values and scientific ethical principles are adopted in practice (MEB, 2018a, p.11).

This quotation gives advice to the science teachers in order to increase students' enthusiasm toward research and scientific thinking. Furthermore, it expects from teachers to teach universal moral values that are important for the scientific research. The code of “scientific ethics norms” also takes place in this quotation as an example of the SE category of the RFN.

The inclusion of the SV category is specifically important for the structure section of the curriculum because it includes the objectives that students are expected to know and apply. Therefore, the frequency of SV in the structure section of the Turkish science curriculum based on grade levels is presented (see Figure 4.11). According to Figure 4.11, the SV category of the RFN is only seen at the 3^{rd} and 4^{th} grade levels with the frequency of 1 and 1. This means that the SV category of the RFN takes place 2 times in the structure section of the curriculum.

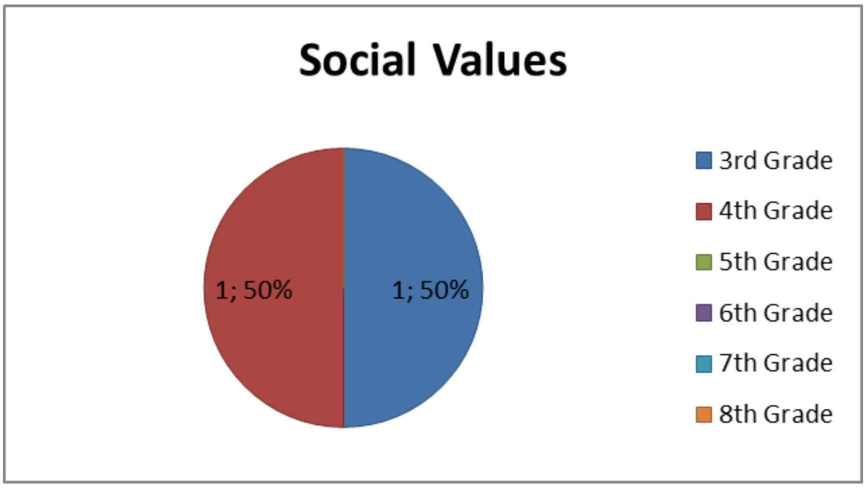

Figure 4.11. Frequency of Codes for Social Values Category of the RFN in the Structure Section of the Turkish Science Curriculum Based on Grade Levels.

The code of “respect for the environment” was referred to for 3rd grade students in the structure section of the Turkish science curriculum as follows:

> In this unit, it is aimed that students distinguish between living and non-living things, get to know the environment they live in, keep it clean, protect and love it… (MEB, 2018a, p. 18).

This quotation took from the explanation of the Living Things and Life unit for 3rd grade and it says how students should behave towards their environments. Keeping the environment clean, protecting and loving environment are some of the aims of this unit.

In summary, the inclusion of the SV category in the Turkish science curriculum is insufficient. For instance, animal care and no harm to people were not explained as SV. Especially, the objectives in the structure section of the curriculum about the SV category are limited with the 3rd and 4th grade levels.

4.1.8. Professional Activities

As seen in Table 4.1, Professional Activities (PA) category of the RFN was indicated 30 times in the Turkish science curriculum. The sections of the Turkish science curriculum that includes the codes about the PA category of the RFN are perspectives, practices of science, engineering, and entrepreneurship, matters to be considered in the application, and structure with the frequency of 2, 2, 3, and 23 respectively. The codes that refer to the PA category of the RFN in the Turkish science curriculum are “presentation” (f=19) and “science fest” (f=11). These codes about PA are exemplified below with quotations. The code of “presentation” is common with the code of “presentation” that was mentioned in the SCD category of the RFN.

The code of “presentation” was referred to in the practices of science, engineering, and entrepreneurship section of the Turkish science curriculum as follows:

> In solving the problem, students compare alternative solutions and choose the appropriate one within the scope of the criteria. By planning for the chosen solution, they are expected to reveal and present the product at the next stage (MEB, 2018a, p. 10).

This quotation focuses on that students create products based on their solutions and then they present their products. In other words, students might have a chance to experience one of the professional activities that scientists make by presenting.

The inclusion of the PA category is specifically important for the structure section of the curriculum because it includes the objectives that students are expected to know and apply. Therefore, the frequency of PA in the structure section of the Turkish science curriculum based on grade levels is presented (see Figure 4.12). According to Figure 4.12, from 3rd grade to 8th grade, the frequency of the codes for the PA category of the RFN changes as 1, 4, 4, 4, 6, and 4, respectively. This means that the PA category of the RFN takes place 23 times in the structure section of the curriculum.

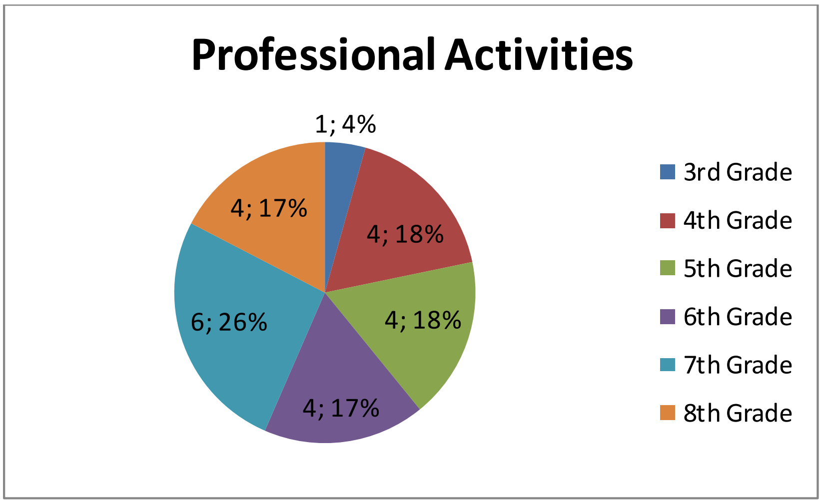

Figure 4.12. Frequency of Codes for Professional Activities Category of the RFN in the Structure Section of the Turkish Science Curriculum Based on Grade Levels.

"Science fest" and "presentation" codes were referred to in the structure section of the Turkish science curriculum as follows:

> Science, Engineering and Entrepreneurship Practices: End of Year Science Festival (Students are expected to present their product effectively during the year) (MEB, 2018a, p.12-13).

Except for the 3rd grade students, this sentence is common for all grade levels from 4th to 8th. It refers to the importance of the science, engineering and entrepreneurship practices in the Turkish science curriculum. Students are expected to make presentations of their products at the science festival that is organized in their schools at the end of the year. The code of "presentation" was referred to for 7th grade students in the structure section of the Turkish science curriculum as follows:

> F.7.4.1.4. Presents by creating various molecular models (MEB, 2018a, p. 42).

This objective expects from students to present the created models about molecules. This means that students can act like a scientist and experience this professional activity.

Briefly, the PA category of the RFN takes place in the Turkish science curriculum more than the other social-institutional categories of the RFN. However, the codes of the PA are not various. This means that only 2 codes that are "presentation" and "science fest" were found as the category of PA in the curriculum. Whereas, teaching professional activities such as attending conferences, publishing articles, and reviewing publications might lead students to understand better what the scientists make as an activity in their professional areas.

4.1.9. Social Organizations and Interactions

As seen in Table 4.1, Social Organizations and Interactions (SOI) category of the RFN was indicated 6 times in the Turkish science curriculum. The section of the Turkish science curriculum that includes codes about the SOI category of the RFN is structure with the frequency of 6. The codes that refer to the SOI category of the RFN in the Turkish science curriculum are "institution" (f=3) and "organization" (f=3).

The inclusion of the SOI category is specifically important for the structure section of the curriculum because it includes the objectives that students are expected to know and apply. Therefore, the frequency of SOI in the structure section of the Turkish science curriculum based on grade levels is presented (see Figure 4.13). According to Figure 4.13, the SOI category of the RFN is only seen at the 7^{th} and 8^{th} grade levels with the frequency of 1 and 5. This means that the SOI category of the RFN takes place 6 times in the structure section of the curriculum.

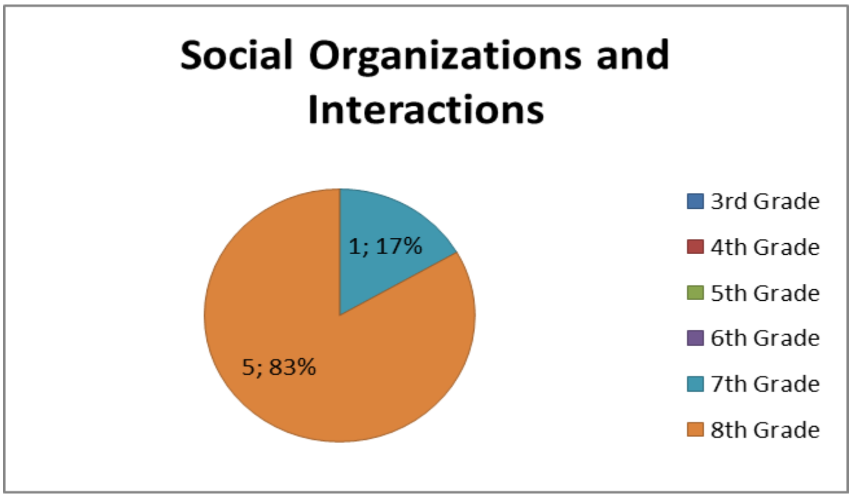

Figure 4.13. Frequency of Codes for Social Organizations and Interactions Category of the RFN in the Structure Section of the Turkish Science Curriculum Based on Grade Levels.

"Institution" and "organization" codes were referred to 7^{th} and 8^{th} grade students in the structure section of the Turkish science curriculum as follows:

> F.7.4.5.4. Pays attention to waste control in its immediate surroundings.
> a. The studies of public and non-governmental organizations related to waste control are mentioned (MEB, 2018a, p. 43).
>
> F.8.4.6.1. Researches the development of the chemical industry in Turkey from past to present.
> a. The studies of public/private institutions and non-governmental organizations that contribute to the development of the chemical industry in our country are mentioned (MEB, 2018a, p. 51).
>
> F.8.7.3.5. Discusses the importance of conscious and efficient use of electrical energy in terms of family and national economy.
> a. Studies carried out by official institutions and non-governmental organizations in our country on energy efficiency and what needs to be done in terms of electrical energy use are stated (MEB, 2018a, p. 54).

Even though social institutions and organizations were not exemplified in these objectives, it may encourage teachers to mention them in their lessons in the topic of waste control, chemical industry, and energy efficiency. However, these references are so superficial and limited to direct teachers. Also, the references only gave general names of the institutions and organizations as public/private institutions and non-governmental organizations.

In summary, except for the structure section that includes the objectives based on the grade levels, the Turkish science curriculum does not represent the category of SOI. Moreover, the codes about the SOI category only were emphasized as bullet points under the objectives as seen in the given references. Nevertheless, these are not enough for students to learn the social organizations and understand their interactions. For instance, laboratories, research centers, and universities were not given as examples of social organizations where scientific knowledge improves. Additionally, the SOI category of the RFN was mentioned on 7^{th} and 8^{th} grade levels in the curriculum even though it may be explained in lower grade levels.

4.1.10. Financial Systems

As seen in Table 4.1, Financial Systems (FS) category of the RFN was indicated 4 times in the Turkish science curriculum. The sections of the Turkish science curriculum that includes codes about the FS category of the RFN are special aims, practices of science, engineering, and entrepreneurship, and matters to be considered in the application with the frequency of 1, 1, and 2 respectively. The codes that refer to the FS category of the RFN in the Turkish science curriculum are "economy" (f=3) and "socio-economic development" (f=1). The code of "economy" was referred to in the matters to be considered in the application section of the Turkish science curriculum as follows:

> In the science course curriculum, the quality of science as an input to practice and economy is given importance. In this context, each unit, subject and objective has adopted an approach that considers the production of technologies to meet the needs of daily life (MEB, 2018a, p. 11).

> Therefore, the process of acquiring science and scientific knowledge will serve the application and production of technological products, adding value to life with entrepreneurial competence and the development of material culture and economic life (MEB, 2018a, p. 11).

The quotations were taken from the same paragraph that refers to the adopted strategies and methods in the application of the curriculum. Based on these quotations, science's impact on the practice and economy is significant for the science curriculum. Moreover, it was emphasized that science affects the technological developments that are related to the economic life.

The inclusion of the FS category of the RFN in the Turkish science curriculum is limited. It was only mentioned that the effect of science on the economy by making relation with technology. The code of "socio-economic development" that is given following section was also looked at the FS category from the similar perspective. Whereas, the funding mechanisms that move the scientific improvements forward might be focused on in order to teach the financial dimension of science deeply.

4.1.11. Political Power Structures

As seen in Table 4.1, Political Power Structures (PPS) category of the RFN was indicated one time in the Turkish science curriculum. The section of the Turkish science curriculum that includes the code about the PPS category of the RFN is practices of science, engineering, and entrepreneurship with the frequency of 1. The code that refers to the PPS category of the RFN in the Turkish science curriculum is "competitiveness of the country" (f=1). The code of "competitiveness of the country" was referred to in the practices of science, engineering, and entrepreneurship section of the Turkish science curriculum as follows:

> It is important for students to experience science and engineering practices in order to increase the scientific research and technological development capacity, socioeconomic development and competitiveness of our country (MEB, 2018a, p. 10).

This statement emphasizes that students should practice science and engineering in classrooms to have a competitive power of the country upon other countries. This means that science and political power structures have a close relationship. Therefore, science teachers should focus on the science and engineering practices to make the country's level better among other countries. In addition to PPS category of the RFN, the code of "scientific research" from the SP category and the code of "socio-economic development" from the FS category take place in the statement.

As a result, it is not enough to give one reference for the PPS category of the RFN in the Turkish science curriculum. This limited inclusion of the PPS causes that both teachers and students ignore the dynamics of power such as gender, race, ethnicity, nationality, and so on in scientific works.

4.1.12. Summary of the Inclusion of the RFN in the Turkish Science Curriculum

The findings of the study show that the Turkish science curriculum includes more references in the cognitive-epistemic categories than the social-institutional categories. Among sections of the curriculum, the structure section that includes units, subjects, and objectives of different grade levels has a big impact on this finding because it includes most of the RFN codes. It can be said that there is a progression from 3rd to 7th grade levels in the total RFN codes. However, when the social-institutional categories were examined, any progression among grade levels was not found. While SP takes place most in the curriculum, PPS take place least in the curriculum. Even though SCD and PA were referred more than the other social-institutional categories, the frequency of these categories is a result of the repetitiveness of the same codes. It means that the social-institutional categories were not represented well in the curriculum. For instance, social organizations were not exemplified and their interactions were not mentioned in the curriculum. Moreover, it was not emphasized how FS and PPS have an effect on science.

4.2. Science Teachers' Views of the RFN and Science Curriculum

The second research question of the study aims to find science teachers' views of the RFN and science curriculum. Therefore, the semi-structured interview protocol and the RFN Questionnaire were applied to the science teachers. The findings of the data analysis that were obtained from the science teachers are presented in sub-sections. Firstly, the findings that were obtained from the RFN Questionnaire were presented. Then, the RFN and science curriculum views of the science teachers were explained respectively based on the interviews. Although the questionnaire was applied to the science teachers after the interviews, the findings of the RFN Questionnaire were presented first. This is because the questionnaire's findings were utilized in the findings of the interviews.

4.2.1. Science Teachers' Views Based on the RFN Questionnaire

Descriptive statistics results of the science teachers who were participated to the study are presented in this sub-section. Descriptive results were obtained from the RFN Questionnaire analysis. Because the number of the participants is low in this study, maximum, minimum, and mean values of them were mentioned based on the analysis of the RFN Questionnaire.

In the Akgun and Kaya (2020)'s study using the RFN Questionnaire, they indicated 200-235 score interval as low, 236-270 score interval as moderate, and 271-305 score interval as high in the context of the RFN understanding. In this study, these score intervals were needed to in order to have a conception about the understanding level of the science teachers. However, it is important to indicate that these score intervals were determined by Akgun and Kaya (2020) for different participant numbers and were applied to this study. Table 4.2 shows each participant's scores of the categories, total scores and understanding levels based on the RFN Questionnaire. The total scores of the science teachers in the RFN Questionnaire are between 248 and 304 out of 350. While the lowest score belongs to the teacher who has a bachelor's degree and the highest teaching experience, the highest score belongs to the teacher who continues to study as a graduate student and is a novice in the profession. Both of these teachers are working in public schools. While 4 of 10 teachers have a Moderate level RFN understanding (M), 6 of 10 teachers have a High level RFN understanding (H) in this study. The mean value of the science teachers' total scores is 278,7 that means H. When the demographic information of the teachers who have M was investigated, it was found that all of them have 7 or more teaching experiences. Also, except for one teacher, all of them who have M have a bachelor's degree.

Table 4.2. The scores and understanding levels of the participants based on the RFN Questionnaire.

Participant Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Aims and Values	27	32	27	28	31	27	24	26	27	22
Scientific Methods	39	27	30	39	24	33	31	27	30	28
Scientific Practices	53	54	51	53	60	61	48	52	50	50
Scientific Knowledge	40	34	33	38	36	45	34	37	32	32
Social-Institutional Aspect	69	67	63	68	68	62	61	61	62	59
Educational Applications	74	66	61	68	76	76	61	71	65	57
Total Score	302	280	265	294	295	304	259	274	266	248
Understanding Level	H	H	M	H	H	H	M	H	M	M

The maximum scores that the science teachers can take for the "Aims and Values (AV)", "Scientific Methods (M)", "Scientific Practices (SP)", "Scientific Knowledge (SK)", "Social-Institutional Aspects (SIA)", and "Educational Applications (EA)" categories are 35, 45, 65, 45, 80, and 80 respectively. AV category scores are between 22 and 32 with the mean of 27,1. M category scores are between 24 and 39 with the mean of 30,8. SP category scores are between 48 and 61 with the mean of 53,2. SK category scores are between 32 and 45 with the mean of 36,1. SIA category scores are between 59 and 69 with the mean of 64. Lastly, EA category scores are between 57 and 76 with the mean of 67,5.

4.2.2. Science Teachers' Views of the RFN

There are 14 questions regarding the RFN in the semi-structured interview protocol (see Appendix C). 2 of the questions were asked to learn general views of the teachers about science and NOS while the rest of the questions were asked to learn views of the teachers about the RFN categories that are "AV, M, SP, SK, SCD, SE, SV, PA, SOI, FS, and PPS". The findings were explained with codes, frequencies of the codes, and quotations.

<u>4.2.2.1. Science Teachers' Views of Science and NOS.</u> The first two questions that were asked to the science teachers are "How would you define science/NOS with your own concepts? What comes to mind when you think of science/NOS?" (Appendix C). According to the teachers, science is an "evidence-based" (f=2), "empirical-based" (f=1), "testable" (f=1), "measurable" (f=1), "subjective" (f=1), and "constantly evolving" (f=1) concept. Also, the teachers made a connection between science and the codes of "knowing" (f=1), "investigation" (f=2), "science in life" (f=1), "people's needs" (f=2), "curiosity" (f=3), "explanation of nature" (f=1), "objective evaluation" (f=1), "creative products" (f=1), "seeking the truth" (f=1), "science branches" (f=2), "perseverance" (f=1), "reporting of research" (f=1), "changeability of knowledge" (f=2), "research steps" (f=1), and "presentation of knowledge" (f=1). Following quotation referred to 3 of the above codes by explaining science.

> How can I define science? In fact, I think it occurred mostly from people's needs. Additionally, I can say in general to create something with the help of curiosity and needs. [Participant 3-M-PRI] (Appendix F-1)

In the science teachers' views of NOS, it was found that some codes are the same as the codes with science. These common codes are "knowing" (f=1), "evidence-based" (f=3), "empirical-based" (f=2), "investigation" (f=3), "science in life" (f=2), "people's needs" (f=1), and "curiosity" (f=2). The reason for common codes formation can be that some teachers did not have enough knowledge about NOS. In other words, some teachers could not differentiate science and NOS. For example, one of the teachers explained her prediction about NOS definition by indicating to use the same definition with science as follows.

> What is called the nature of science is probably the features of the nature of science, that is, peculiar to science. How? Conceptually, the nature of science varies. Again, I will talk about similar things. It is the information obtained based on evidence, data, experimentation, and observation. [Participant 7-M-PU] (Appendix F-2)

In this quotation, the emphasis of evidence and data expresses the code of "evidence based" while the emphasis of experimentation and observation expresses the code of "empirical-based". Moreover, the codes of "accessing SK" (f=2), "being improvable" (f=2), "being innovative" (f=1), "working principles of science" (f=2), "scientific methods" (f=1), "features of science" (f=1), "history of science" (f=1), and "the core of science" (f=1) were generated.

To sum up, the science teachers defined science and NOS from different perspectives. Therefore, a lot of codes were generated. However, even though all science teachers said something about science and NOS, some of them repeated the same things with science while defining NOS. Furthermore, the teachers used mostly the code of "curiosity" for the definition of science while they used mostly the codes of "evidence-based" and "investigation" for the definition of NOS.

4.2.2.2. Science Teachers' Views of the Aims and Values of Science. To learn science teachers' views of the Aims and Values of Science (AV), it was asked "What do you think the aims and values of science mean? What examples can you give of the aims and values of science?" (see Appendix C). All science teachers gave examples about the aims of science. Most of the teachers explained aims of science as "understanding the universe" (f=3), "explanation of events" (f=2), "solving problems" (f=2), "serving to humanity" (f=4), "searching for truth" (f=2), and "ease of life" (f=2). One of the explanations was presented below.

> I think that the aim of science should be to serve humanity first and foremost. We all see together how much science has served in the pandemic period we are currently experiencing. If it weren't for vaccines, we wouldn't really be alive right now anyway. I think the aim of science is huge. [Participant 10-M-PU] (Appendix F-3)

Furthermore, some of the teachers emphasized "explanation of Earth" (f=1), "human satisfaction" (f=1), "increasing of knowledge" (f=1), "helping other disciplines" (f=1), "educational aims of science" (f=1), and "making connections among times" (f=1) as aims of science. The code of "human satisfaction" means that science satisfies human materially or spiritually with its results.

3 of the science teachers (Participants 3, 6, and 8) did not give examples of the values of science. Participant 3 has a moderate level RFN understanding while Participant 6 and 8 have high level RFN understandings based on the RFN Questionnaire and their AV scores in the questionnaire are below the AV mean as can be seen Table 4.2. "Objectivity" (f=2), "complying with ethical values" (f=3), and "intellectual honesty" (f=2) are mostly referred values that the science teachers mentioned. Additionally, "intellectual property" (f=1), "doing no harm" (f=1), "continuity" (f=1), "importance of science" (f=1), and "being independent" (f=1) were seen as values of science by some of the science teachers. The emphasis on "importance of science" actually shows a naïve understanding because the teacher (Participant 7) mentioned the reasons that make science valuable instead of mentioning scientific values.

For the AV category, the science teachers mostly referred to the good points such as serving to humanity, searching for truth, intellectual honesty, and so on. However, some teachers do not have a comprehensive understanding to explain AV. When these science teachers' scores of AV in the RFN Questionnaire were examined, it was seen that their naïve explanations reflected to the questionnaire. This means that there is a consistency between AV scores and interview findings to a great extent.

<u>4.2.2.3. Science Teachers' Views of the Scientific Methods and Methodological Rules.</u> To learn science teachers' views of the Scientific Methods and Methodological Rules (M), it was asked "What do scientific methods mean? What examples of scientific methods can you give?" (see Appendix C). While some science teachers started to answer the questions by explaining the meaning of M, some science teachers started to answer the questions by giving examples of M. The teachers defined M as "methods used during research" (f=1), "research steps" (f=2), "ways to access scientific knowledge" (f=1), "daily life applications" (f=1), and "educational methods" (f=1). The "research steps" were exemplified as identifying problems, observation, data collection, constructing hypothesis, conducting experiments, and so on by the high level science teachers (Participants 1, 5). This code is a sign that these teachers have a misconception about M. Furthermore, "measurement" (f=2), "testing" (f=2), "observation" (f=7), "experimentation" (f=5), "modeling" (f=1), "using materials" (f=1), "qualitative and quantitative methods" (f=1), and "hypothesis, theory, and law" (f=1) are the examples of M that gave by the science teachers. The emphasis of hypothesis, theory, and law shows that the science teacher (Participant 9) confused M with types of the SK or has a misunderstanding. Participant 7 who has 12 years of teaching experience explained M by using mostly referred codes that are "observation" and "experimentation" as follows.

> Scientific methods are actually ways to reach scientific knowledge. These are methods such as experimentation and observation in modern science. [Participant 7-M-PU] (Appendix F-4)

All science teachers respectively indicated that M has "subjectivity" (f=10) and "domain specificity" (f=10) aspects when it was asked "Are the scientific methods used by scientists uniform?" and "Do scientific methods differ according to different branches of science? Or are the same scientific methods used in all branches of science?". The meaning of "subjectivity" refers to the variety in scientific methods while the meaning of "domain specificity" refers to the different scientific methods in different branches of science according to scientists' views. In contrast to "domain specificity" of M, 2 of the science teachers (Participants 5 and 6) thought that M has a "specific structure" even though they emphasized that M changes in different branches of science. The teacher emphasized that M has a specific structure by indicating research steps as follows.

> I think it differs. Now, I'm not a person who has such great domain dominance on this subject. But when we establish logic, yes there are certain scientific methods. In line with their research, people choose the most right one for themselves from these scientific methods. But of course, I think that the path they will follow should be the same in general terms. First forming an idea, then observing it, doing research. Then I think it should move forward to justify it on something. [Participant 5-H-PRI] (Appendix F-5)

In conclusion, the science teachers' views of M show variety. There are some misconceptions like in the code of "research steps". In addition to this, some science teachers made unrelated connections with "daily life applications", and "educational methods" while explaining the category of M. On the other hand, it is good that all science teachers stated "subjectivity" and "domain specificity" as aspects of M.

<u>4.2.2.4. Science Teachers' Views of the Scientific Practices.</u> To learn science teachers' views of the Scientific Practices (SP), it was asked "What do scientific practices mean? What examples of scientific practices can you give?" (see Appendix C). Only 2 science teachers (Participants 1 and 4) answered this question confidently because they probably heard this concept before. On the other hand, 3 science teachers (Participants 2, 3, and 9) indicated that they do not know the meaning of SP. After the question was asked in different ways, they tried to explain SP. The remaining science teachers made inferences about the meaning of SP and examples of SP from the term of SP. While some science teachers started to answer the questions by explaining the meaning of SP, some science teachers started to answer the questions by giving examples of SP. The teachers defined SP as "agreed practices" (f=1), "practical science" (f=1), "science making" (f=2), and "practices used during science teaching" (f=1). These definitions show that the teachers have naïve views of the SP category. Furthermore, "making prediction" (f=1), "observation" (f=2), "modeling" (f=2), "experimentation" (f=3), "testing" (f=1), "doing research" (f=3), "discussion" (f=1), "presenting reports" (f=1), "asking questions" (f=1), "data" (f=1), "daily life" (f=1), and "end-products" (f=2) are the examples of SP that gave by the science teachers. In the following quotation, the science teacher emphasized 5 of these codes that are "experimentation", "doing research", "discussion", "data" and "presenting reports".

> In scientific practices, things like knowledge, more precisely…Is it called knowledge? We search for knowledge or we do an experiment. As a result, we access data. What are we doing with this data? We are discussing it with someone or presenting reports about it. [Participant 4-H-PU] (Appendix F-6)

Consequently, both cognitive-epistemic and social-institutional categories of science were exemplified as SP by the science teachers. The codes of "experimentation" and "doing research" are the dominant codes that were emphasized by the teachers. There are also some naïve views about SP. When the teachers who have a high SP score in the RFN Questionnaire were investigated, their views of SP were found as limited and naïve. In this respect, it can be said that there is an inconsistency between the findings of questionnaire and interview. Moreover, it was realized that Participants 1 and 4 who answered the SP questions more confidently than other teachers have a score on the border of the SP mean in the RFN Questionnaire.

4.2.2.5. Science Teachers' Views of the Scientific Knowledge. To learn science teachers' views of the Scientific Knowledge (SK), 3 questions were asked. One of the questions asks "What does scientific knowledge mean?" (see Appendix C). 3 of the science teachers (Participants 2, 4, and 5) defined SK as "certificated knowledge". The SK definition of Participant 4 who is novice in teaching was given below.

> Scientific knowledge is actually the knowledge we obtain as a result of studies approved by certain authorities, that is, by some institutions interested in science, through referees. [Participant 4-H-PU] (Appendix F-7)

Almost all science teachers answered the question by mentioning the features of SK. According to them, SK is "proven" (f=5), "testable" (f=1), "measureable" (f=1), "consistent" (f=1), "falsifiable" (f=2), "reliable" (f=1), "objective" (f=1), and "accurate" (f=1) knowledge. Also, it was emphasized that SK has a "cumulative development" (f=3). Other question asks "Are there different types of scientific knowledge? If so, what are they?" (see Appendix C). Except for one science teacher (Participant 4) who is a novice in teaching, other teachers are "non-awareness of SK types" (f=9). One of the explanations of science teachers who do not have an idea about types of SK was presented as follows.

> Different types of scientific knowledge. I mean, I can't think of anything right now. It's been a while since we went to university, yes, we forgot. [Participant 9-M-PRI] (Appendix F-8)

On the other hand, Participant 4 said that "theory", "law", and "hypothesis" are the types of SK. The last question in the interview is "Can scientific knowledge change over time?" (see Appendix C). All of the science teachers supported the idea of "changeability of SK" (f=10) and most of them gave examples that explained the changeability of SK. One of these examples was given below.

> Of course it (SK) changes over time. I can show the easiest thing in physics. For a very long time in physics, life was based on mechanics. In other words, we had the physical information that we gathered under the title of mechanics. But later, the relativity that came on top of this, for example, caused a lot of information we know to change. [Participant 2-H-PU] (Appendix F-9)

To sum up, the features of SK such as provability and falsifiability were indicated mostly while defining SK. Although the science teachers defined SK easily, almost all of them could not tell the types of SK. Only Participant 4 who has been working in a public school for a year stated "theory", "law", and "hypothesis" as the types of SK. However, none of the teachers mentioned models as a type of SK.

<u>4.2.2.6. Science Teachers' Views of the Social-Institutional System.</u> To learn science teachers' general views of the social-institutional system, it was asked "Does science have social and institutional aspects? If so, what could it mean? What examples of social and institutional aspects of science can you give?" (see Appendix C). All science teachers expressed their opinions about the social-institutional system. Their opinions were categorized under the codes of "social certification and dissemination" (f=5), "social, cultural, and ethical values" (f=10), "professional activities" (f=1), "scientific institutions" (f=2), "financial systems" (f=4), and "political power structures" (f=9). "Social certification and dissemination" code includes sharing of knowledge, attending conferences, publishing in articles, and reliability of knowledge. An example was presented about the code of "social certification and dissemination" below.

> Of course, science has a social aspect. Even, there is a social aspect of science like this: In the simplest terms, conferences, as everyone would think. For example, scientists are doing research.

> What are they doing them? They present them at conferences. They publish notices. [Participant 4-H-PU] (Appendix F-10)

"Social, cultural, and ethical values" code includes the reciprocal influences between social and cultural values and science, daily life relationships of science, and ethical restrictions. Also, "professional activities" code includes working in cooperation. Moreover, the code of "scientific institutions" consists of places where science is developed such as universities and research institutions. While "financial systems" code includes financial support, financial institutions, and economy, "political power structure" code includes governments, politics, interests of governments/institutions, racism, and injustice. Following quotation is an opinion of Participant 2 who made connection between "financial systems" and the social-institutional system.

> People who do research need to be financially supported because doing research is costly and takes time. It has to be funded from somewhere. This fund has to be largely covered by institutions. In these respects, it may have an institutional aspect. [Participant 2-H-PU] (Appendix F-11)

Additionally, some science teachers (Participants 9 and 10) made connections with "social sciences" (f=1) such as sociology and anthropology and "technology" (f=2) when they heard the concept of the social-institutional system. The common aspects of these teachers are that they have a moderate level RFN understandings and bachelor's degree.

In conclusion, the science teachers' views of the social-institutional system have parallels with the RFN categories. They referred to the SCD, SE, SV, PA, SOI, FS, and PPS categories of the RFN by using different terms. In addition to these categories, "social sciences" and "technology" were seen related to the social-institutional system by some science teachers who have moderate level RFN understandings. Findings about each social-institutional categories of the RFN that were obtained from the specific category questions were presented below.

4.2.2.6.1. Science Teachers' Views of the Social Certification and Dissemination. To learn science teachers' views of the Social Certification and Dissemination (SCD), it was asked "What do you think the social certification and dissemination process in science means? In other words, how do scientists share their works?" (see Appendix C). Based on the science teachers' SCD explanations, the codes of "sharing studies with other scientists" (f=2), "sharing studies with society" (f=4), "evaluation of studies" (f=1), "repeatability of studies" (f=1), and "acceptance of studies" (f=4) were generated. "Repeatability of studies" means that studies on the same topic are repeated in different ways by different scientists. Moreover, "acceptance of studies" means the approval of studies by societies. The following quotation summarizes the meanings of other three codes that include sharing and evaluation processes of studies.

> Of course, scientists have to share something they do and share it with other scientists because something they produce alone does not get approval, of course. And nothing is added to it or it is not evaluated. Therefore, of course, scientific knowledge or these studies are shared with the society. In this way, its reliability and validity increase. [Participant 1-H-PRI] (Appendix F-12)

Additionally, "reliability/validity" (f=3), and "networking" (f=2) were seen as the results of SCD while "needing a lot of time" (f=2), and "having science language" (f=1) were seen as prerequisites of the SCD by the teachers. How the teachers made a connection between "reliability/validity" and SCD was exemplified in the end of the above quotation. On the other hand, the code of "having science language" that was said in return for explaining how scientists share their works was exemplified in the following quotation.

> How do they share? For once there must be a ground for them to share. Now, for example, this is why science has a common purpose. Latin, you know, is like a common language in science, especially in physical sciences. [Participant 10-M-PU] (Appendix F-13)

Furthermore, "dissemination issues" (f=2), "reliable knowledge issues" (f=2) were emphasized as problems that are faced during SCD. The code of "dissemination issues" draws attention to limited dissemination of science while the code of "reliable knowledge issues" draws attention to information pollution that stems from more information. On the other hand, except for Participant 8 who has SIA score below mean, science teachers mentioned dissemination channels that are "publications (articles, encyclopedia, books, journals)" (f=14), "broadcastings (internet, e-mail, television, social media, websites, databases)" (f=10), "conferences" (f=2), and "schools/universities" (f=3).

To sum up, all science teachers made coherent comments about the category of SCD. Most of them made relations with the sharing of studies with societies and accepting of studies by societies when the SCD category was asked. Also, there were generated rarely mentioned codes like "evaluation of studies", "repeatability of studies", and "having science language". Furthermore, the science teachers put forward a lot of examples for dissemination channels of science.

4.2.2.6.2. Science Teachers' Views of the Scientific Ethos. To learn science teachers' views of the Scientific Ethos (SE), it was asked "What does you think scientific ethos mean? In other words, do scientists follow certain norms during their works and in their working processes with other scientists? What might these norms be if they follow?" (see Appendix C). Almost all science teachers supported that scientists should follow certain norms. Only Participant 3 who has a moderate level RFN understanding did not sure whether there are norms in scientific works and focused on "limitations of SE" (f=1). The teacher who has 13 years of teaching experience expressed her confusion with these sentences:

> If I have to say my own interpretation, the ethos has to be, of course. But I can also guess, or at least I think it can be: If you stick to very moral and ethical situations, progress will be made to some extent. I think that every knowledge or every scientific data cannot be reached in this way. But on the other hand, of course, there is a side that should not lose its ethos. [Participant 3-M-PRI] (Appendix F-14)

On the other hand, Participant 8 who has a high level RFN understanding could not give examples of norms although he thought that there are norms in scientific works. His score of SIA in the questionnaire is lower than the mean score. The science teachers thought that "transparency" (f=1), "being free from bias" (f=1), "confidentiality" (f=1), "originality" (f=1), and "intellectual honesty" (f=3) are significant. Participant 2 with a high RFN understanding level sorted some examples about "confidentiality" such as keeping participants' personal information secret with numbers during the scientific process and not sharing the name of participants. Furthermore, the science teacher who is a doctoral student at the same time referred to more codes than the other science teachers. This teacher mentioned "transparency" and "intellectual honesty" as follows.

> The scientific ethos, of course, the thing is, the data set becomes open, transparent. To be able to give, present and explain research methods in detail. After that when the dataset you get needs to be transparent. Well, after that, of course, honesty about participants, for example. To give the correct information about the participants. [Participant 7-M-PU] (Appendix F-15)

Other codes about SE are “respect for intellectual property” (f=5), “respect for opinions” (f=1), and “animal care” (f=1). As can be seen, the “respect for intellectual property” code that includes using references and paying attention to plagiarism are the most referred code in the SE category. “Applying sanctions in violations” (f=1) was presented as a precaution against violations of scientific ethos by one of the teachers. “Collaboration” (f=1), “literature review” (f=3), “valid methods and participants” (f=1), and “working disciplines” (f=1) also were generated as codes of SE. According to Participant 9 who has a moderate level RFN understanding, the “working disciplines” code that was detailed as research-based, evidence-based, and empirical-based were seen as norms of scientists.

Except for one science teacher who has a bachelor’s degree, all of the participants have an idea about norms that scientists follow. In contrast to this teacher, the teacher who is studying for a doctorate mentioned 5 of the codes in the SE. This can be a result of taking a part in scientific works. On the other hand, any correlation between other demographic information and SE views of the science teachers was not found.

4.2.2.6.3. Science Teachers’ Views of the Social Values. To learn science teachers’ views of the Social Values (SV), it was asked “What do you think the social values of science mean? What examples of the social values of science can you give?” (see Appendix C). 3 of the science teachers (Participants 2, 3, 9) thought that there are similarities between the categories of SE and SV. Therefore, they repeated some of the SE codes for the SV. These similar codes are “confidentiality” (f=1), “animal care” (f=1), and “intellectual honesty” (f=1). Moreover, Participant 5 did not understand the question at first and answered the question after the question was asked in a different way. Like in the SE, the explanation of Participant 8 about SV is also weak. The dominant code about the SV category of the RFN is “related to society” (f=4). The teachers who emphasized this code probably made a prediction from the name of the SV. The following quotation has exemplified this situation.

> Social values of science… When I think of the social values of science, I think a little more about its relation and effect with society. [Participant 1-H-PRI] (Appendix F-16)

Other codes that were generated about SV are "ethics" (f=1), "communication" (f=2) among scientists and people, "objectivity" (f=1), and "social utility" (f=2). The code of "social utility" was explained as follows by one of the teachers who has a bachelor's degree.

> Social values of science… I never thought about it. So what could be the social values of science? I can say anything that makes people's lives easier because… What kind of benefit science can have in social life? Time is very precious in our social life right now. I think science is something that allows everyone to do everything easier, faster. [Participant 10-M-PU] (Appendix F-17)

Moreover, "clear explanations for societies" (f=1), "giving value human" (f=1) which refers to a humanistic view, and "ethical permission" (f=1) which is taken from ethical commissions were stated by some teachers.

In summary, the science teachers' views of the SV were found as limited based on the interviews. Some of the teachers thought that SV is similar to the SE category of the RFN while some of the teachers made predictions from the meaning of SV.

4.2.2.6.4. Science Teachers' Views of the Professional Activities. To explore science teachers' views of the Professional Activities (PA), it was asked "Do scientists engage in professional activities? If they engage in professional activities, what might they be?" (see Appendix C). 3 of the science teachers (Participants 3, 6, 8) needed more explanations to be able to answer this question. Professional activities of teachers were given as an example to make the question more understandable for the teachers. Half of the science teachers thought that "sharing of studies" (f=5) is a professional activity that scientists engage in. Furthermore, "attending conferences" (f=5), "attending symposiums" (f=3), "attending meetings" (f=2), "attending scientific activities" (e.g. TEKNOFEST) (f=1), and "organizing workshops" (f=3) were indicated as professional activities. Participant 4 who is working in a public school emphasized mostly dominant codes that are "attending conferences" and "sharing of studies" as follows.

> Yes, they are involved in professional activities. In fact, the purpose of papers and conferences is to provide a professional working opportunity, to bring people together. When these people get together, they talk about their work. [Participant 4-H-PU] (Appendix F-18)

Other codes about PA that were referred less are “working in cooperation” (f=1), “evaluation of studies” (f=1), “being professionally competent” (f=1), “making an experiment on themselves” (f=1), and “scientific research processes” (f=1) including literature review, data collection, data analysis, and so on. Additionally, Participant 8 who has a bachelor’s degree stated “daily life activities” such as playing golf as professional activities as seen in the following quotation.

> What activity can be? I mean, even playing golf can be learned very quickly for a scientist, or very easily grasped. It can be an activity that can be achieved very easily to the point of success. [Participant 8-H-PRI] (Appendix F-19)

As can be seen, “being professionally competent”, “making an experiment on themselves” and “daily life activities” codes reflect the naïve views of the science teachers about PA. On the other hand, the teachers (Participants 6 and 8) who mentioned these codes as PA have a high RFN understanding as general, but their social-institutional aspect scores are low of the mean in the questionnaire.

In conclusion, some of the science teachers did not understand the concept of PA when it was asked first-time. Thus, professional activities of teachers were given as an example by the researcher. However, these teachers continue to have a naïve views. In contrast to the naïve views, there are also dominant codes that show competent views. Furthermore, having a high level RFN understanding in the RFN Questionnaire is not an indicator of competent PA views because social-institutional aspect scores can be lower than the mean.

4.2.2.6.5. Science Teachers’ Views of the Social Organizations and Interactions. To investigate science teachers’ views of the Social Organizations and Interactions (SOI), 2 questions were asked. One of the questions asks “What do you think social organizations and interactions mean?” (see Appendix C). Some of the science teachers indicated that there is “collaboration among scientists” (f=1) and “interaction among institutions” (f=4).

Participant 9 who is working in a private school made a relation between "interaction among institutions" and the development of science by indicating the following quotation.

> There is definitely interaction. For example, as I said before, NASA was the first in the world in space exploration. And after that, TESLA, for example, started to conduct space research for itself. And there is definitely interaction. Otherwise, I think that science cannot develop. [Participant 9-M-PRI] (Appendix F-20)

Additionally, the codes of "related to human" (f=2) and "finance-science interaction" (f=1) were generated. The code of "related to human" includes the relationship of organizations with individuals and societies. The code of "finance-science interaction" states a funder and researcher and emphasizes the interaction between them. The science teachers also indicated the benefits of social organizations. These benefits are "providing a certification" (f=2) and "providing planned SK" (f=2). In other words, some science teachers thought that social organizations are needed because they make the scientific process easier by certification and planning of knowledge. The other question that was asked to the science teachers is "Where can scientific knowledge be produced?" (see Appendix C). Most of the teachers thought that SK can be produced "free from any place" (f=6). A quotation from a teacher who is a graduate student was presented below.

> Scientific knowledge can be produced anywhere. In other words, it is unnecessary to put it into an institution, a policy or just a certain segment. Of course, going through an education can make it easier. But I think the place where scientific knowledge is produced is unlimited, that is, independent of the place. [Participant 6-H-PU] (Appendix F-21)

Additionally, the science teachers gave many examples of places where scientists produce SK such as "laboratories" (f=3), "universities (f=5), "schools" (f=2), "research centers" (f=1), "relief organizations" (f=1), "voluntary organizations" (f=1), "government institutions" (f=2) (e.g. TÜBİTAK, NASA, and ESA), "foundations" (f=1), "non-governmental organizations" (f=1) (e.g. ERG), and "companies" (f=2) (e.g. TESLA)". On the other hand, it was found that the teachers who have low scores in social-institutional aspect of the questionnaire explained SOI more limited than the others. For examples, Participant 10 who has the lowest score in social-institutional aspect category of the questionnaire gave only schools as an explanation of the questions.

In summary, the science teachers' views of SOI show variety. In other words, the teachers made connections from different perspectives such as finance and certification while explaining SOI. Furthermore, there are varieties in the examples of institutions where scientific knowledge is produced. However, there are also some limited explanations that were faced in the teachers with low score of social-institutional aspect of the questionnaire. Thus, it can be said that this category of the RFN questionnaire and interview findings are consistent.

4.2.2.6.6. Science Teachers' Views of the Financial Systems. To learn science teachers' views of the Financial Systems (FS), it was firstly asked "Is there a relationship between financial systems and science? If so, what kind of relationship is there?" (see Appendix C). Almost all science teachers directly stated that there is a "relationship between FS and science" (f=8). Although other science teachers (Participants 3 and 7) did not use the term relationship directly, they talked about their thoughts that support the relationship between FS and science. "Sponsorship" (f=7) is a dominant code of FS that was mentioned mostly related to the codes of "private sector funding" (f=2), "governmental funding" (f=1), "self-funding" (f=1), and "funding for urgent needs" (f=1). The following quotation is referred to the code of "sponsorship".

> When financial systems are mentioned, as far as I understand, the financial dimension of this businessand the provision of suitable environments or opportunities for it to work in this sense come to mind. Of course, a financial infrastructure may not be necessary for the emergence of knowledge. But I think that in order to prove it, to research it, to make observations, to justify it, and to be accepted by everyone, there is absolutely a need for funding. [Participant 5-H-PRI] (Appendix F-22)

The code of "funding for urgent needs" means to give funds for urgent needs such as funding for vaccine of Covid-19 and mucilage in Sea of Marmara. Furthermore, "interests of institutions" (f=3), "marketing of scientific products" (f=2), "commodification and commercialization of science" (f=1) codes were generated based the answers of the teachers. While the "interests of institutions" code means to give funds in accordance with the interests of institutions, the "marketing of scientific products" code means to be needed money for the marketing of scientific products. Additionally, "commodification and commercialization of science" means that the money is sometimes gotten ahead of science itself by scientists. Another question that was asked in the interviews is "Do scientists need money when conducting scientific research?" (see Appendix C). Mostly referred code about this question is "expenses of research" (f=6) such as expenses for materials and sources. Also, the science teachers thought that "money for basic needs" (f=3) and "money for a scientific career" (f=1) are needed. The answer of the novice teacher is shown below.

> I wish it wasn't, but unfortunately you can't make scientific research unless it's financially supported because doing any experiment can sometimes take years, as we just talked about. People need to continue their own lives or scientific studies require materials and infrastructure. Sometimes a material, for example, the speed of a collider from CERN can reach millions of dollars. Therefore, being financially funded requires enormous strength. Unfortunately, they are very relevant. [Participant 2-H-PU] (Appendix F-23)

All science teachers stated the relationships between science and financial systems by giving examples. In other words, they thought that money is necessary for science. Most of the science teachers indicated that "sponsorship" is a requirement for making scientific research because of the "expenses of research". As a result, any naïve views about FS were not found.

4.2.2.6.7. Science Teachers' Views of the Political Power Structures. To learn science teachers' views of the Political Power Structures (PPS), it was asked "Is there a relationship between the political power structures and science? If so, what kind of relationship is there? Is science affected by political power structures?" (see Appendix C). All science teachers said that there is a "relationship between PPS and science" (f=10). However, Participants 9 and 10 who have lower scores than the mean of social-institutional aspects of the questionnaire abstained before explaining their views of PPS. Then, they gave a few details about the PPS category of the RFN with the help of the encouragement of the researcher. Especially, the teacher who is working in a public school for 21 years indicated firstly that he cannot say anything about politics. On the other hand, the science teachers indicated that governments have an effect on science by emphasizing "interests of governments" (f=2), "governmental/political constraints" (f=5), "ideological constraints" (f=3), and "governmental/political supports" (f=4). This means that not only constraints but also supports of governments on science were given as examples of PPS. One of the quotations that explain both sides of PPS was presented below.

> There is definitely a political relationship as well. Governments can give more support to studies that will serve their own interests or they block some of them. They may not allow some studies to be done. [Participant 1-H-PRI] (Appendix F-24)

In addition to effects of PPS on science, only Participant 6 who has the highest level RFN understanding mentioned "effects of science on PPS". Additionally, "commodification and commercialization of science" (f=1), "international relations" (f=2), "racism" (f=1), and "PPS for dissemination" (f=1) are the codes that were generated based on the science teachers' views. The code "international relations" involves competition and cooperation among countries. The code of "PPS for dissemination" implies that PPS is needed to disseminate scientific knowledge.

Briefly, the science teachers thought PPS mostly from the negative perspectives. For instance, they stated political and ideological constraints that scientists face with. In contrast to these codes, a few science teachers indicated that scientific works increase with the help of political support. Furthermore, some teachers abstained to explain their ideas about PPS. These teachers have moderate level RFN understandings and low scores in the social-institutional aspect of the questionnaire.

4.2.3. Science Teachers' Views of the Science Curriculum

There are 11 questions regarding the science curriculum in the semi-structured interview protocol (see Appendix C). The questions are related to the science curriculum, NOS implementation, and the inclusion of NOS in the science curriculum. Findings that were obtained from answers to these questions were provided respectively with suggestions of the science teachers. The findings were presented with codes, frequencies of the codes, and quotations.

<u>4.2.3.1. Science Teachers' Views on Features of the Science Curriculum and Their Suggestions.</u> Before starting to ask deep questions about the curriculum, it was aimed to learn what extend the science teachers use the science curriculum. Based on the findings, 7 of the science teachers stated "completely the usage of the curriculum" while 3 of the

science teachers (Participants 1, 5, and 8) stated “partially the usage of the curriculum” in their lessons. It was realized that the teachers who were using the curriculum partially are working in private schools. One of the science teachers working in a private school indicated her usage of the curriculum as follows.

> When we say do I use the curriculum, we can say what I am using and what I am not using. I am not completely independent. It means that I am not disconnected. But of course, if you say do you use it one hundred percent, no, I don't. [Participant 5-H-PRI] (Appendix F-25)

Furthermore, when the answers of the teachers who use completely the curriculum were investigated, it was found that all of them talked about the structure section which includes the objectives of subjects. This means that the science teachers mostly pay attention to the objectives because they are expected to implement the objectives. A teacher from a public school explained this situation as follows.

> The curriculum mainly includes objectives. There are subjects in the curriculum. There is also a beginning part. There may be topics in this part. But the beginning part sometimes may not reflect on the objectives. We have to use the objectives in the annual plan. We even have to write them in the lesson notebook. Therefore, of course, I teach my lessons by putting those objectives in the center. [Participant 7-M-PU] (Appendix-26)

To learn general views of science teachers about the science curriculum, it was asked “Does the science curriculum meet your expectations? Do you think there is any deficiency?” (see Appendix C). 3 of the science teachers (Participants 1, 5, and 6) stated that the science curriculum is “theoretically well”. However, 2 of them (Participants 5 and 6) also stated that the curriculum is “practically not applicable” due to the examination system, deficiency of physical opportunities, and non-competent teachers. Furthermore, the science teachers’ views on the science curriculum can be separated as positive and negative sides of the curriculum. The positive sides of the curriculum were coded as “spiral structure” (f=1), “fewer details” (f=1), “time for activities” (f=1), “interactions among stakeholders” (f=1), “interdisciplinarity” (f=1), and “metacognitive skills” (f=1). On the other hand, negative sides of the curriculum were coded as “open-ended objectives” (f=1), “deficiency of details” (f=2), “lack of connection” (f=4), “deficiency in knowledge” (f=1), “lack of inquiry” (f=1), “intensive curriculum” (f=2), “time-management issues” (f=3), and “rote learning” (f=1). “Intensive curriculum” and “time-management issues” are codes that support each other because time problems were mostly seen as a result of the intensive curriculum. When the codes were investigated, it was realized that having few details is seen as both positive and negative sides of the science curriculum by different science teachers. In contrast to these teachers' views, some teachers thought that the science curriculum is intensive.

The following question that was asked in the context of the science curriculum is "What are your suggestions regarding these deficiencies?" (see Appendix C). The science teachers indicated that the science curriculum should "be skill-based" (f=1), "be reflected in books" (f=1), "be developed by professionals" (f=1), and "be simplified" (f=1). Additionally, according to some teachers, the curriculum should "include information management" (f=1), "include revisions" (f=1), and "include more details" (f=1). As can be seen, a contradiction between two science teachers was found like happening in the positive and negative sides of the curriculum. One of the teachers (Participant 9) supported the simplification of the curriculum while another teacher (Participant 10) supported more details in the curriculum.

To sum up, the Turkish science curriculum is used mostly by the science teachers who are working in public schools with the aim of applying objectives in lectures. Moreover, the science teachers mentioned both negative and positive features of the curriculum. The codes of "lack of connection" and "time-management issues" are the dominant codes that were mentioned as negative features of the curriculum. Some contradictions were also found among science teachers. For example, a feature of the curriculum was seen both as positive and as negative by different science teachers. This situation was also observed in the suggestions of the teachers.

4.2.3.2. Science Teachers' NOS Implementations and Suggestions. To understand how science teachers implement the NOS to their lessons, it was asked "Do you teach your students the nature of science in your science lessons? How?" (see Appendix C). The science teachers gave a lot of different examples from their science lessons related to the NOS integration. For instance, they said that they give importance "using argumentation "(f=1), "using the question-answer method" (f=2), "using student-centered activities" (f=2), "using models" (f=2), and "using scientific sources" (f=2) in order to implement NOS to the lessons. Furthermore, "emphasizing changeability of SK" (f=3), "emphasizing changeability of M" (f=1), "expecting evidence-based explanations" (f=1), "gaining scientific process skills" (f=1), "conducting experiments" (f=5), "making observations" (f=1), "doing research" (f=2), and "making inferences form results" (f=1) were seen as examples of NOS integrations. An explanation of one of the teachers about how she used the changeability of SK in her lessons is given below.

> Also, I mentioned too much about the changeability of knowledge. For example, I can't remember exactly which one it was but… Was it an opinion of Aristotle? I'm giving an opinion from an old time. I say it's like this. But years later, Galileo came and said like this and showed how something that has been accepted over the years has changed. I gave them as examples in my lesson. The children were surprised at how it was accepted for years. They had seen that knowledge could change in an instant. [Participant 1-H-PRI] (Appendix F-27)

Lastly, there were generated the codes of "giving examples from daily life" (f=3), "giving characteristics of scientists" (f=1), and "giving examples from the history of science" (f=1) based on the science teachers' answers.

To learn implementation suggestions of the science teachers, it was asked the teachers "What are your suggestions about teaching and including the nature of science in lessons?" (see Appendix C). Mostly referred codes are "integration of NOS to the curriculum" (f=4), "increasing of NOS sources" (f=3), and "using learning by doing" (f=2). One of the experienced teachers expressed the idea of "integration of NOS to the curriculum" as the following.

> Moreover, there are many ways of inclusion of NOS in the curriculum. It can be included in many ways apart from experimentation. The life of scientists was only expressed. But, for example, how did scientists do this? How did they reach that knowledge? Which scientist, which... It is only in the history of the atom. That's all. [Participant 7-M-PU] (Appendix F-28)

In addition to these codes, the teachers suggested "providing collaboration among teachers" (f=1), "allowing students to feel free" (f=1), "creating small groups" (f=1), "providing in-service teacher training" (f=1), "increasing opportunities of schools" (f=1), "presenting NOS as an elective course" (f=1), and "simplifying curriculum" (f=1). "Creating small groups" was seen as beneficial for NOS implementation because it gives chance to students gain more experience. "Increasing opportunities of schools" was given a suggestion because the teacher thought that opportunities for laboratories should be improved to implement NOS. The teacher who has 2 years of teaching experience expressed his suggestions by emphasizing both "providing in-service teacher training" and "integration of NOS to the curriculum".

> I don't know if it (NOS) is directly mentioned as an objective in the curriculum, but it can be included as an objective because our roadmap is the curriculum. I think it would be a little more beneficial if this is included in the curriculum and if it is given to teachers as in-service training because it is very difficult for people who are unaware of the nature of science to teach the nature of science. Thus, I think it can happen after creating awareness about it. [Participant 6-H-PU] (Appendix F-29)

As a result, NOS implementations of the science teachers showed variety. Half of the teachers stated that they conducted experiments as an example of NOS implementation. On the other hand, any relationship between the participants' demographic information and presenting NOS implementations was not found. This means that all science teachers implemented more or less NOS in the context of their NOS understandings. As suggestions, integration of NOS into the curriculum and increasing of NOS sources were mostly mentioned.

<u>4.2.3.3. Science Teachers' Views of the Inclusion of NOS in the Science Curriculum.</u> To learn views of the science teachers about the inclusion of NOS in the science curriculum, it was asked "Are there any emphases on the nature of science in the science curriculum? If any, which components were highlighted?" (see Appendix C). While 5 of the science teachers (Participants 3, 4, 5, 6, and 10) mentioned explicitly "inclusion of NOS" in the science curriculum, 3 science teachers (Participants 7, 8, and 9) mentioned explicitly "deficiency of NOS" in the curriculum. Moreover, most of the science teachers told that "experimentation" (f=6) and "observation" (f=5) take place mostly in the science curriculum. For instance, Participant 1 who is a graduate student stated these codes like that:

> I guess there are mostly experiments. There are objectives in the style of doing something by experimenting with this and that. Apart from that, there are observations as far as I can remember. Umm, I cannot remember anything else right now when I think of the objectives and the curriculum. [Participant 1-H-PRI] (Appendix F-30)

Other codes that the teachers made connections with NOS and thought that they take place in the curriculum are "types of SK" (f=1) (e.g. theory, law), "scientific process skills" (f=1) (e.g. exploration, investigation), and "scientists" (f=2) (e.g. Newton, Pascal). As categories of the RFN, science teachers said that "aims of science" (f=2), "scientific methods" (f=2), and "scientific practices" (f=1) are emphasized in the curriculum. There were also generated two codes about the social categories of science that are "exclusion of social categories" (f=2) and "deficiency of social categories" (f=2). The codes of "aims of science" and "exclusion of social categories" were indicated by one of the science teachers as follows.

> Maybe the aim of science is a bit but not too much. In other words, the aim of science is not mentioned much. The value and importance of science is not mentioned. It has no social or political meanings or anything. [Participant 7-M-PU] (Appendix F-31)

On the other hand, Participants 3, 6, and 8 did not give detailed explanations and they only indicated whether NOS is included in the curriculum. One of the teachers associated the limitation of his NOS views with the limited inclusion of NOS in the curriculum. In addition to these findings, Participant 10 who has 21 years of teaching experience indicated that the aim of the science curriculum is not to teach the NOS. Therefore, he thought that the emphasis of the NOS in the curriculum is enough.

To sum up, some teachers stated the inclusion of NOS in the Turkish science curriculum while some teachers stated the deficiency of NOS in the curriculum. Also, some teachers did not give examples that show the inclusion of NOS in the curriculum even though they thought the inclusion of NOS. As a general, experimentation and observation are the codes that the science teachers emphasized more. Moreover, 4 of the science teachers indicated that the social-institutional categories of the RFN do not take place or take place in a minimum level.

4.2.3.4. Science Teachers' Suggestions of the Inclusion of NOS in the Science Curriculum.

To learn suggestions of the science teachers about the inclusion of NOS, it was asked "Should the nature of science be included in the science curriculum? How can it be included? What are your suggestions?" (see Appendix C). Except for Participant 4, all science teachers stated "importance of NOS on the curriculum". In other words, they thought that NOS should be included in the science curriculum. On the other hand, Participant 4 indicated that the curriculum already includes NOS and did not present any suggestion. Other science teachers suggested that the curriculum should "include SK" (f=2), "include M" (f=4), "include more research" (f=2), "provide NOS examples" (f=2), "emphasize NOS explicitly" (f=1), "include NOS as a topic" (f=1), and "integrate NOS to objectives" (f=1). The code of "provide NOS examples" refers to examples that gave cues to teachers about NOS. Some of these suggestions were given by the teachers with 7 and 2 years of experience respectively in the following quotations.

> It (NOS) should be given. There may be a hidden emphasis that has not been clearly emphasized as I have just mentioned. But their (students') realization... Yes, the nature of science is a very broad term. It may not be a single image, but a topic that can support their imagination a little more. And this may even be a course title that can support this subject and perhaps at this point, their imagination should be advanced with different fields not with a single teacher, like science in order to answer different questions in their minds. [Participant 8-H-PRI] (Appendix F-32)

> It (NOS) should be included because if we think of science as a piece of puzzle, if a piece is missing, it will never be complete. Therefore, the nature of science should definitely be included. How? For example, it can be integrated to the objectives. [Participant 6-H-PU] (Appendix F-33)

In brief, the science teachers gave some suggestions on how NOS should be included in the science curriculum. Among the categories of the RFN, it was suggested that scientific knowledge and methods should take place in the science curriculum. In general, it can be said that the suggestions are limited because the variation of the codes are few.

<u>4.2.3.5. Science Teachers' Interpretations of the Quotations in the Science Curriculum from NOS Perspective.</u> It is important to learn how science teachers interpret the science curriculum from the RFN perspective. Therefore, there were presented to the science teachers 5 quotations from the science curriculum. Then, it was asked "Do you think this purpose/objective is related to the nature of science? If so, which component or components of the nature of science do you think has to do with it?". Because the categories of the RFN are new terms for most of the participants, it was also indicated that the questions during the interview reflect the categories of the RFN and reminded the categories. All science teachers thought that all quotations are related to NOS. However, some teachers' explanations showed that their views are insufficient to interpret its

relationship with the RFN. For example, for the 4th quotation that is "Presents the observation results of a plant's life cycle. It is expected to monitor the development of a plant for a certain period of time and to record the observation results" (MEB, 2018a, p.18) (see Appendix C- Question 28), one of the teachers who has a moderate level RFN understanding gave the following answer before the RFN categories were reminded.

> There is. I will say that yes whatever comes my way on this subject. As I already said, it's a subject in it. They're already intertwined. But what does it have to do with? Another creature... How is the nature of science part? I can't find an answer by thinking about it. [Participant 3-M-PRI] (Appendix F-34)

On the other hand, some teachers gave the reasons why they thought the quotation is related to the RFN category. For instance, a dialog between the researcher and the teacher who has a high level RFN understanding for the 4th quotation (see Appendix C- Question 28) was given below.

> Participant 1: This gets into the scientific practices. I mean, to observe, to record, to present, perhaps. The concept of presenting results may be important here.
>
> Researcher: Where would you put the presentation? Scientific practices?
>
> Participant 1: Presenting actually feels a bit like a social here because others are scientific stuff, methods. I mean, it goes into scientific practices. But presenting is a little superficial, the word he used there. But it still adds a meaning when it is said presenting. It's like sharing. [Participant 1-H-PRI] (Appendix F-35)

Furthermore, it can be said that there is a consistency between the comments of the RFN categories and interpretations of the quotations from the curriculum. In other words, while the science teachers' views of the RFN were limited, their interpretation skills also were found as limited. For instance, 2nd quotation that is "To help understand how scientific knowledge is created by scientists, the processes that this knowledge goes through and how it is used in new research" (MEB, 2018a, p.9) (see Appendix C- Question 26) was given to the teachers and one of the science teachers who gave limited explanations about the RFN categories interpreted this quotation like that:

> Of course, they are still interconnected. I can't separate much. Since I do not want to give the same answers again, I can say that I proceeded in the same mindset. [Participant 8-H-PRI] (Appendix F-36)

Because some science teachers' views of the RFN are superficial, the terms that take place in the quotations of the curriculum misguided the teachers. This situation can be seen in the 5th quotation (see Appendix C- Question 29) that was coded as the categories of SP and SOI. 5th quotation is that "Discusses the importance of conscious and efficient use of electrical energy in terms of family and national economy. The studies carried out by official institutions and non-governmental organizations in our country on energy efficiency and the things to be done in terms of electrical energy use are stated" (MEB, 2018a, p.54). Although the quotation is emphasized SP and SOI categories, some of the teachers thought that the FS category of the RFN is emphasized. This is probably because of the term economy that takes place in the quotation. For the 1st quotation that is "In the process of discovering nature and understanding the relationship between human-environment, adopting scientific process skills and scientific research approach and producing solutions to the problems encountered in these fields" (MEB, 2018a, p.9) (see Appendix C- Question 25), the science teachers mostly made connections with the social aspects of science because of the emphasis on human and environment. However, these teachers could not give a specific category from the social-institutional categories of the RFN. Lastly, all of the science teachers interpreted the 3rd quotation that is "To ensure the adoption of universal moral values, national and cultural values and scientific ethical principles" (MEB, 2018a, p.9) (see Appendix C- Question 27) properly by indicating the codes of SV, SE, and social aspects of NOS. But, the teachers' interpretations can also be stemmed from the terms of moral values, national and cultural values, and scientific ethical principles in the quotation without any consciousness.

To sum up, all science teachers agreed that the given quotations are related to the NOS. However, some of the teachers' interpretations were found as limited or false while explaining the relationship between quotations and the categories of the RFN. This situation can be stemmed from the limited RFN views. This is because the science teachers who interpreted the RFN categories limited also interpreted the relationship between quotation and the RFN categories limited.

4.2.4. Summary of the Science Teachers' Views of the RFN and Science Curriculum

Many questions were asked in the interviews to learn the science teachers' views about the RFN and science curriculum. The RFN views of the teachers were also compared with findings of the RFN Questionnaire. According to the findings of the questionnaire, it was found that the science teachers have a high RFN understanding level on the mean. However, there are also some limitations of the teachers in the explanation of the RFN categories and interpretation of the inclusion of the RFN in the science curriculum. Therefore, not only consistencies but also inconsistencies between the findings of the analysis of data from the questionnaire and interview were found based on the RFN categories. On the other hand, a consistent relationship with the demographic information of the science teachers was not found.

Even though competent views in each category of the RFN were found, there are also incompetent views that the science teachers have. For example, some teachers had a difficulty to define the SP and PA categories of the RFN. Also, the M category caused a well-known misconception and the types of SK were not defined most of the science teachers. Additionally, the SE and SV categories of the RFN were seen as the same by some teachers. On the other hand, AV and FS categories were mostly explained well. Moreover, aspects of SK and dissemination channels in SCD were exemplified well by the science teachers.

For the curriculum views of the science teachers, firstly, their usage of the curriculum was investigated. The science teachers said that they use the science curriculum to some extent. However, it was realized that the curriculum mostly means the objectives of subjects for the teachers. Moreover, public school teachers use the curriculum more systematically than the private school teachers. According to the teachers' views, lack of connection and time management issues were mostly emphasized as negative sides of the curriculum. In the implementation of NOS in classrooms, experiments and daily life examples were preferred more. Inclusion of the experiments as NOS example in the curriculum also was seen as mostly referred code. Additionally, the science teachers mostly thought that the social-institutional categories of the RFN do not take place in the science curriculum because they could not give examples about these categories. It was suggested that NOS should be included in the curriculum more and increase the number of NOS sources by the science teachers. Lastly, it can be said that the RFN views of the teachers reflect to the interpretations of the quotations in the curriculum.

5. DISCUSSION

The chapter of discussion includes firstly the discussion of the findings of curriculum analysis and science teachers' views in the context of the RFN. Then, the implications of the study, limitations of the study, and recommendations for further research are presented.

5.1. Discussion of the Findings

In this section, the discussion of the study findings is presented under the two sub-sections by supporting with previous studies. First of all, the inclusion of the RFN in the Turkish science curriculum was discussed both from the perspectives of the cognitive-epistemic and social-institutional categories of the RFN. Then, the science teachers' views of the RFN and science curriculum were discussed one by one.

5.1.1. Inclusion of the RFN in the Turkish Science Curriculum

The findings of the Turkish science curriculum analysis show that the frequency of the codes is 610 in the context of the RFN. So many codes were generated from 58 pages of the science curriculum because the codes are repeated throughout the curriculum not only with different words but also with the same words. The codes that give the same meaning were collected under the same code and category. Therefore, the high frequency of the codes is not enough to say that the RFN is included well in the Turkish science curriculum. The Turkish science curriculum should include the RFN systematically by taking into consideration the progression among grade levels.

Furthermore, 525 of the codes belong to the cognitive-epistemic categories of the RFN while 85 of the codes belong to the social-institutional categories of the RFN. This means that the cognitive-epistemic aspects of science were referred to more than the social-institutional aspects of science in the Turkish science curriculum that was published in 2018 by the National Ministry of Education. This finding is parallel with the study of Okan (2021) that was examined 5^{th}, 6^{th}, 7^{th}, and 8^{th} grade Turkish science textbooks using in 2020-2021 education term from the RFN perspective. This means that the Turkish science textbooks also referred to the cognitive-epistemic categories more than the social-institutional categories. Kaya and Erduran (2016a) investigated the Turkish science curricula that were published 2006 and 2013 and faced with the similar findings including less social-institutional emphasis. International curriculum analysis findings were also presented that the cognitive-epistemic categories were emphasized more than the social-institutional categories (e.g. Cheung, 2020; Yeh *et al.*, 2019). Other finding of the present study shows that SP is the dominant category among the cognitive-epistemic categories while PA is dominant category among the social-institutional categories. Moreover, the frequency of SCD codes was found close to the PA category. This is because the same code that is “presentation” was assigned to both of these categories. In contrast to the dominant categories, AV is the least mentioned category among the cognitive-epistemic categories while PPS is the least mentioned category among the social-institutional categories. When these findings were compared with Okan (2021)’s textbook analyses, it is possible to say that both of the studies reached the similar findings with minor differences.

The Turkish science curriculum was separated into 11 sections by the developers of the curriculum and all sections were examined based on the RFN categories by the researcher. The findings of the analysis showed that 469 of 610 codes belong to the “structure section”. The structure section that includes units, subjects, and objectives of the grade levels from 3^{rd} to 8^{th} constitutes 43 pages out of 58 pages of the curriculum. This means that the high page number is a possible reason to have a high code number in the structure section. On the other hand, any code was not found in the sections of the “assessment and evaluation approach” and “result”. The assessment and evaluation approach section includes general assessment and evaluation principles belonging to all branches of curricula. In other words, assessment and evaluation principles are not special to science education. This can be a reason for not founding any code about the RFN. The result section includes the revision process of the curriculum. So, it can be accepted normal to find no codes about the RFN. When the progression of the RFN among grade levels in the structure section was investigated, it was seen that the total code frequencies decrease from 7th grade to 3rd grade. 8th grade level has the second highest code frequency in this progression. The same progression is also valid for the cognitive-epistemic categories of the RFN according to the content analysis of the study. The number of objectives can be a reason for the progression among grade levels because 7th grade level has the most objectives while 3rd grade level has the least objectives. Therefore, it cannot be said clearly that there is a systematic RFN progression in the Turkish science curriculum. This finding is also valid for the Swedish curriculum for 1-9 grade levels (Leden & Hansson, 2015). They stated that although NOS takes place in the Swedish curriculum, any progression among grade levels was not found (Leden & Hansson, 2015). Furthermore, Olson (2018) found only one document that contains NOS consistently among nine science standards documents. Goren (2021) who investigated Turkish middle school students' RFN understandings found that 7th and 8th graders have high mean scores and understandings based on the RFN Student Questionnaire and interviews. This can be meant that the students who used the science curriculum published in 2018 were affected from the inclusion of the RFN in the curriculum as directly proportional. This is because 7th and 8th grade levels in the Turkish science curriculum contain more codes about the RFN. Below, the inclusion of the cognitive-epistemic and social-institutional categories in the Turkish science curriculum was discussed respectively one by one.

<u>5.1.1.1. Cognitive-Epistemic Categories of the RFN.</u> Aims and Values of Science (AV) is one of the cognitive-epistemic categories of the RFN. The frequency of the AV category in the Turkish science curriculum found as 41 and it includes the least code number among the cognitive-epistemic categories. Moreover, the structure section includes most of the code numbers (12 out of 41). It is also important how AV was included in the curriculum. Some direct quotations that explain AV were given in the present curriculum. Kaya and Erduran (2016a) also indicated that there are direct statements about AV in the Turkish science curricula published in 2006 and 2013. "Finding solution for problems" and "novelty" codes are frequently used codes and it is thought that these codes represent AV well. However, it could be integrated other AV such as objectivity, accuracy, critical examination, and decentralizing power that were proposed by Erduran and Dagher (2014a). Furthermore, 7th grade level that has most codes in total and most of the categories does not include any AV codes. This can be a sign that there is no progression among grade levels in the AV category.

Methods and Methodological Rules (M) is another category of the cognitive-epistemic system. Based on the findings, M is the second least mentioned category in the Turkish science curriculum and the structure section includes most of the code numbers (31 out of 49). Moreover, the availability rate of the M in the structure section is much more than the AV availability. In other words, the M category is given directly to students with objectives more. However, no emphasis of non-hypothesis testing and non-manipulative description in the curriculum was found, and a limited focus on hypothesis testing and manipulative description was found. Erduran and Dagher (2014b) gave advice to the Junior Cycle Science curriculum in Ireland that students are taught some scientific methods are manipulative and some others are not.

Another cognitive-epistemic category of the RFN is Scientific Practices (SP). It was found that most of the categories belong to the SP category in the Turkish science curriculum. Okan (2021) also indicated that SP was highlighted most in her Turkish science textbook analysis. Therefore, it can be said that there is a consistency in the reflection of the curriculum to the textbooks in the context of the SP. The number of SP codes is parallel with the variety of SP codes. This means that there is also code variety in the category of the SP. "Explanation", "observation", "discussion", and "experimentation" are highly emphasized SP codes in the curriculum. The generated SP codes have similarity with the Turkish science curricula published in 2006 and 2013 (Kaya & Erduran, 2016a) and chemistry curriculum published in 2013 (Kaya & Erduran, 2016b). Furthermore, it can be said that there is a partially progression among grade levels because the frequency of codes increased from 4^{th} to 7^{th} grade levels.

The last category of the cognitive-epistemic system is Scientific Knowledge (SK). It is the second dominant category of the RFN in the Turkish science curriculum. The curriculum mostly mentioned the scientific knowledge and knowledge as concepts. However, this is not enough to teach the significance of SK for students. The codes about the features of scientific knowledge which includes formulation of knowledge, cumulative development of knowledge, and tentativeness of knowledge should be increased. Erduran and Dagher (2014a) indicated teaching of how SK is formed in which criteria is important for students' understandings. Furthermore, although some few references to the examples of law, theory, and model separately were given, their interactions to generate scientific knowledge were not mentioned. This situation is also valid for the Turkish middle school science textbooks (Okan, 2021).

To sum up, there are some insufficiencies in the inclusion of the cognitive-epistemic categories in the Turkish science curriculum although the frequency of the codes is seen relatively as high. Furthermore, only progression is seen in the total code number from 3rd to 7th grade level. However, when each cognitive-epistemic category that is AV, M, SP, and SK was investigated, a consistent progression among grade levels was not found.

5.1.1.2. Social-Institutional Categories of the RFN. Social Certification and Dissemination (SCD) is one of the social-institutional categories of the RFN. According to the findings of the study, it is the second most mentioned category of the social-institutional system in the Turkish science curriculum. However, generally, the inclusion of SCD can be seen as insufficient because there is no emphasis on certification and ways of dissemination. Therefore, it can be used more references that focus on peer-review, validation, certification, and dissemination ways such as journals, conferences, and so on. Okan (2021) found in her Turkish science textbook analysis that the content section of the textbooks does not represent SCD well while the activity section of the textbooks represents SCD more and suggested to increase the emphasis of certification and ways of dissemination.

The other social-institutional category is Scientific Ethos (SE). The inclusion of the SE category in the Turkish science curriculum is quite a few based on the content analysis findings. Kaya and Erduran (2016a) also found no codes that represent SE in the 2006 and 2013 science curricula. This means that there is no progression among Turkish science curricula in the inclusion of SE. One of the probable reasons for this situation can be that the curriculum developers think of SE as independent from science education or as difficult for students’ understandings. On the other hand, the reflection of SE into the science-related textbooks was also found as limited according to both national (e.g. Okan, 2021; Sayın, 2021) and international studies (BouJaoude *et al.*, 2017; Park *et al.*, 2020).

For instance, BouJaoude *et al.* (2017) indicated that the SE category was found only in one of the three science textbooks with one frequency.

Social Values (SV) is another social-institutional category of the RFN and its inclusion in the Turkish science curriculum is not sufficient to teach SV. Moreover, there is only one code for 3rd and 4th grade levels in the structure section of the curriculum. This means that higher grade levels were not given direct objectives to teach SV. This can be stemmed from that curriculum developers see SV as different from science education as Okan (2021)'s implication.

Professional Activities (PA) has the highest code frequency among the social-institutional categories. Although the number of the codes is relatively high, the variety of the codes is limited with the codes of presentation and science fest. In other words, the repetitiveness of the same codes is the reason for the PA frequency. Whereas, scientists take part in many professional activities such as attending conferences, writing articles, publishing in journals, searching funds, organizing projects, and so on (Irzik & Nola, 2014). Thus, the variety of PA can be reflected to science curricula.

Social Organizations and Interactions (SOI) that is one of the social-institutional categories of the RFN was mentioned superficially in the Turkish science curriculum. Kaya and Erduran (2016a) also indicated that 2013 Turkish science curriculum emphasized SOI implicitly. This is a sign that science curricula did not revised by taking into consideration the SOI category of the RFN. Direct references that emphasize universities and research centers as social organizations can be added (Kaya & Erduran, 2016a). According to the findings of the study, few codes of SOI were generated in 7th and 8th grade levels even though other grade levels did not include any codes.

Financial Systems (FS) is one of the least referred categories of the RFN in the Turkish science curriculum. This situation is also viable for previous curricula and textbooks analyses. For instance, Sayın (2021) concluded that only 12th biology and chemistry textbooks include one or two FS references. Okan (2021)'s findings also showed little emphasis of the FS category in the middle school science textbooks. Also, BouJaoude *et al.* (2017) did not find any codes about FS in the 9th grade Lebanese textbooks. Furthermore, any codes of FS were not found in Turkish science-related curricula (Kaya & Erduran, 2016a; Kaya & Erduran, 2016b).

Last category of the social-institutional system is Political Power Structures (PPS). Only one code about PPS that is about the competitiveness of the country was found in the curriculum content analysis. This can be stemmed from the idea that PPS should be excluded from science or there is no relationship between PPS and science. Cheung (2020) who examined the Hong Kong biology curriculum did not found any codes about PPS.

The inclusion of the social-institutional categories of the RFN in the Turkish science curriculum is not enough to teach these categories to students. The previous curriculum and textbooks analyses also supported these findings of the study. On the other hand, if the social-institutional system of science is not given to students, their understandings might be limited in the context of scientific works and science development (Erduran & Dagher, 2014a).

5.1.2. Science Teachers' Views of the RFN and Science Curriculum

The findings that were obtained from science teachers are discussed by taking into consideration of the previous studies' findings. This sub-section includes the discussion of the science teachers' views of the RFN and science curriculum.

<u>5.1.2.1. Science Teachers' Views of the RFN.</u> Both findings of the RFN Questionnaire and interviews of the science teachers are discussed in the context of the RFN here. The results of the RFN Questionnaire show that the science teachers of the study have moderate and high level RFN understandings with the mean of high level RFN understanding. In other words, any teacher who has low level RFN understanding based on the questionnaire was not found. This can be the result of selecting participants purposefully from the researcher's environment. When science teachers' RFN understanding levels and their demographic information were compared, it was realized that there is a relationship

between RFN understanding levels and teaching experience. The science teachers who have seven and more teaching experience have moderate level RFN understanding while the science teachers who have five and less teaching experience have high level RFN understanding. This can be a result that highly experienced science teachers forget the theoretical NOS knowledge that was learned in the university or they never learned NOS in their university times. On the other hand, any relationship between other demographic information of the science teachers such as gender, school type, and educational status and their RFN understanding levels was not found. Saif (2016) also indicated that informed NOS conceptions of science teachers do not change based on gender as a result of a questionnaire analysis. However, the results of the RFN Questionnaire are not enough to have a comprehensive knowledge about science teachers' views of the RFN. Therefore, interviews were conducted with the teachers before the questionnaire. Interview findings presented some naïve views of the science teachers about the RFN categories in addition to good explanations. Okan (2021)'s findings of science teachers' NOS perceptions also are in line with these findings. She stated that although her participants have high RFN levels as a result of the questionnaire, naïve views were found in the some categories as a result of the interviews (Okan, 2021). Moreover, Azninda *et al.* (2021) stated that good explanations about social-institutional aspects were not presented although teachers have high scores in this category of the RFN Questionnaire. This can be a result of interview questions. In other words, interview questions in this study can affect the questionnaire scores of the teachers.

Before starting to discuss each category of the RFN, the science teachers' views of science and NOS itself were learned with the help of the interviews. The findings show that some teachers could not define NOS and used the same words with the definition of science. This can be a result of that NOS did not take place in science teachers' trainings. The findings of Saif (2016) and Aksoz (2019) also depicted that some science teachers have insufficient NOS views based on the assessing NOS aspects.

The science teachers' views of Aims and Values of Science (AV) were found consistent in between the AV score of the RFN Questionnaire and interview findings to a great extent. This is because naïve views of AV belong to the teachers who took below mean score in AV category of the questionnaire. On the other hand, some of the generated codes such as serving to humanity, understanding the universe, and complying with ethical values were referred more as AV in the study. The other studies conducting with in-service and pre-service teachers (e.g. Okan, 2021; Kaya *et. al.*, 2019) also generated similar codes about AV.

For the Methods and Methodological Rules (M) category of the RFN, it was found that some science teachers do not have a proper view. Some of them mentioned research steps as a misconception probably because they learned M from the books like that. This finding is also obtained in Kaya *et al.* (2019)'s study with pre-service science teachers and in Okan (2021)'s study with science teachers. Moreover, some teachers mentioned unrelated things while explaining M. This was probably stemmed from their limited M knowledge.

It was found that Scientific Practices (SP) is one of the unknown terms for the science teachers because most of the teachers were needed more explanations. They also did not make sure their explanations. On the other hand, it was interesting that the teachers who a have high score in the SP category of the questionnaire made limited and naïve explanations. Additionally, the teachers who presented good explanations took scores on the border of the SP mean. These findings showed that the interviews' findings are inconsistent with the RFN Questionnaire results. The reason for this inconsistency can be that the items in the questionnaire reminded teachers their previous knowledge of SP. Okan (2021) indicated that the reason of naïve views can be the term of practice means easy to apply in Turkish. In the present study, the codes of experimentation, observation, and modeling were generated as dominant SP examples that the science teachers mentioned. These codes are also common with Erduran *et al.* (2021)'s study that was conducted with Turkish and English pre-service science teachers.

The findings of Scientific Knowledge (SK) are mostly in line with the studies in the literature. Except for one science teacher, none of the teachers told the types of SK such as theory, law, and model as in the studies of Okan (2021) and Kaya *et al.* (2019). This can be a result of the textbooks did not emphasize theory, law, and model as types of SK because

Okan (2021) mentioned this deficiency in her middle school textbooks analysis. Mıhladız and Dogan (2014) also indicated that science teachers showed naïve views about the types of SK. In order to transfer types of SK to the students, teachers should know these concepts and their interactions. In this way, students might understand the validity of a scientific knowledge and usage in other disciplines (Erduran & Dagher, 2014a).

General views of the science teachers about the Social-Institutional System refer to the social-institutional categories of the RFN. For instance, the codes of SCD, FS, and PPS were generated as a result of the teachers' interviews. Aksoz (2019) and Demirel (2021) also generated similar codes from the teachers in their studies. This finding showed that the science teachers have good views about the social-institutional system as Okan (2021) implied. Furthermore, Erduran *et al.* (2021) indicated that pre-service science teachers in Turkey looked at social-institutional system of science from a lot of perspectives like in this study. These can be stemmed from that this system is closely related to daily life.

The findings of the science teachers' interviews showed that all science teachers have an idea about the Social Certification and Dissemination (SCD) category of the RFN. Even though Aksoz (2019) mentioned the limited perceptions of the teachers, it was seen that the science teachers explained SCD from different perspectives in the present study. Dissemination channels and facing issues during SCD are common findings of both of these studies that were obtained from teachers.

It can be said that the educational status of the science teachers affected the explanations of the Scientific Ethos (SE). While the science teacher who is a doctoral student gave many examples of SE, one of the science teachers who has a bachelor's degree could not give any example of SE. This may be a result of the positive effect of graduate education on the teacher. In other words, because doctoral students experienced scientific research by taking attention to SE, they can know more than bachelor's degree students.

It was found that there are some common codes in between Social Values (SV) and SE based on the findings of the interviews. Okan (2021) also stated that the teachers mentioned about similar codes in SV and SE. Moreover, Aksoz (2019) presented the findings of SV and SE under the single heading. On the other hand, the findings of the present study showed that the science teachers' views of SV were limited to some extent.

Like happening in the SP category of the RFN, Professional Activities (PA) was seen uncertain by some science teachers. Therefore, they presented some naïve views about PA. The reason for uncertainty of PA can be that the term of activity evokes activities in everyday or hobbies. For instance, playing golf was seen as PA by one of the science teacher. Okan (2021) also mentioned one of her participants saw motivational activities as PA in her study.

There is a consistency between the social-institutional aspect category of the RFN Questionnaire and interviews in the context of the science teachers' views of Social Organizations and Interactions (SOI). Moreover, as in the Aksoz (2019)'s study, teachers mentioned a lot of institutions where scientific knowledge is produced such as schools, universities, laboratories and so on.

It was found that all science teachers support the idea of relationship between science and Financial System (FS). This finding is also valid for the science teachers in Okan (2021)'s study. Also, the teachers in the study made good explanations that exemplify FS. This can be a result of that the finance is a necessity in all daily life activities. Because of that, the teachers can be made good connections between science and FS.

All of the science teachers have an idea about Political Power Structures (PPS) according to the findings. This can be stemmed from the inclusion of PPS in daily life. Not only positive sides of the politics on science but also negative sides of the politics on science generated as dominant codes. On the other hand, two of the participants who have moderate level RFN understandings abstained to mention their thoughts of PPS. This situation also can be a result of politics.

In brief, it was found that most of the science teachers have superficial knowledge about NOS. Also, most of them did not know the categories of the RFN. However, the teachers' interpretation skills of the RFN categories are not denied because they made good comments while explaining the RFN categories. On the other hand, some categories were not understood and thus naïve views and misconceptions appeared. Mostly, any relationship among demographic information of the science teachers and their views of the RFN was not found. In contrast to this finding, Demirel (2021) indicated in her study that science teachers who are graduate students have high RFN views.

5.1.2.2. Science Teachers' Views of the Science Curriculum. Respectively, the views of the science teachers about the Turkish science curriculum, implementation of NOS, and inclusion of NOS in the curriculum are discussed with their suggestions. First of all, it was found that the Turkish science curriculum is used mostly by the teachers who are working in public schools. This is probably because of the accountability of public schools. In other words, while some private schools can follow different curricula or make revisions in the curriculum, public schools have to follow the curriculum as the main source within its framework. Furthermore, it was found that the teachers mostly mentioned the objectives in the curriculum. There were faced with some contradictions that stemmed from different science teachers' views in the context of the features of the curriculum and suggestions. This is understandable because they explained their own views about the features of the curriculum.

The implementations of NOS in the science lectures are in line with the previous studies that were conducted with teachers. In this study, the experimentation was indicated as the commonly used implementation example. At the same time, experimentation was seen mostly referred NOS emphasis in the Turkish science curriculum. This can be a reason for that the teachers implemented experimentation more in lectures. Demirel (2021) also stated in her study that the experimentation is applied by all science teachers because it takes place in the lesson units. The other NOS implementations that the science teachers emphasized are daily life examples, models, argumentation, and student-centered activities. Kaya *et al.* (2017) who gave place each RFN category implementation of the science and chemistry teachers also found the same codes in their study. On the other hand, in the study, there is no example that the science teachers integrate social-institutional categories of the RFN into their classroom implementations. Kurup (2014) stated that the social aspects of science implementations are challenging for the science teachers based on a study conducted with six science teachers. This can be a reason for not founding examples about social-institutional categories in the present study. As suggestions, integration of NOS to the curriculum and increasing of NOS sources were referred more than the others by the science teachers. In addition to these suggestions, there were given some common suggestions with Aksoz (2019)'s study such as NOS as an elective course, in-service NOS training, and opportunities of schools. In-service NOS training for teachers is important because when they feel competent about NOS, they can integrate their knowledge into the lectures (Kaya *et al.*, 2018).

The inclusion of the NOS in the Turkish science curriculum based on the science teachers' views is another finding of the study. Like happening in the implementation of the teachers, it was said that the experimentation is referred to most in the curriculum by the teachers. From the categories of the RFN, some science teachers thought that the cognitive-epistemic categories referring to AV, M, SK, and SP take place in the curriculum while some teachers thought that the social-institutional categories take place limited or never in the curriculum. Demirel (2021) also stated that her participants agreed superficial emphasis of social-institutional categories in the curriculum. These findings are consistent with the findings of the Turkish science curriculum's analysis in the present study. Therefore, it can be said that the science teachers aware of NOS inclusion in the science curriculum.

Except for one science teacher, all teachers agreed that NOS should take place in the science curriculum. The other teacher thought that NOS is already mentioned in the curriculum and did not give any suggestion. Kaya *et al.* (2018) indicated that integration of the social-institutional categories into the syllabuses is significant because these shape the teachers' implementations. The teachers in the present study mostly focused on M and SK categories of the RFN when their suggestions were asked. This can be a result of that these teachers' views were limited with these categories. On the other hand, providing NOS examples that supported the implementation of NOS, more research that supported students' research abilities, mentioning NOS explicitly under a topic or as objectives were given as suggestions.

It is important that the science teachers interpret the science curriculum from the NOS perspective. Therefore, the teachers' NOS interpretations of quotations in the science curriculum were found. In general, the teachers thought that the quotations have a relationship with NOS. However, mostly limited explanations were presented by the teachers. This can be a result of the limited RFN views. This means that there is a consistency between science teachers' RFN views and their interpretations of quotations. Demirel (2021) also found that teachers who have limited NOS views could not make connections with the science curriculum. On the other hand, Irez *et al.* (2018) stated that although most of the science teachers showed informed views about most of the NOS aspects, they could not interpret the inclusion of NOS in some scenarios. Thus, it can be said that an informed NOS view is not enough to transfer NOS into the lectures (Irez *et al.*, 2018).

5.2. Implications of the Study

The study has significance because the findings of the study present a lot of implications for different stakeholders such as policy makers, curriculum developers, teachers, and educators. The implications of the study have the potential to improve the inclusion of the RFN in the curriculum and implementation of the RFN in the classroom environment. The suggestions of the participants were benefited from while explaining the implications.

It was found that to some extent, there is a progression among grade levels in the context of the RFN inclusion of the curriculum. However, this progression was seen as imbalanced when it was looked at category by category. In other words, it is necessary to consider the inclusion of the categories of the RFN among grade levels. Instead of fluctuations among grade levels, the RFN should be integrated systematically and holistically to the science curriculum. Moreover, as one of the participants in the study said, the RFN emphasis in the curriculum should be more explicit. In this way, teachers can understand the importance of RFN and teach to students in lectures. However, in the present science curriculum, some of the categories of the RFN were mentioned superficially. Therefore, it is hard for these categories to be implemented in the classrooms. Additionally, the curriculum might include implementation examples about the RFN. Thus, teachers' implementations of the RFN can get easy. The integration of the RFN to the curriculum might also trigger the integration of the RFN in the textbooks. As a result, it may be achieved that the students understand science from the RFN perspective.

Secondly, integration of the RFN to the curriculum and textbooks by oneself cannot be effective. It is important to give pre-service and in-service teacher trainings about the RFN because teachers are the practitioners of the RFN in classrooms. Therefore, teachers should have a competent understanding about the RFN categories. However, the findings of the study show that the participants have some naïve views about the RFN categories although they mostly have a high RFN understanding level. Teacher trainings can be organized to increase teachers' RFN awareness. However, these trainings should include activities that the teachers can implement in classrooms. Thus, teachers might have more enthusiasm to attend these trainings.

5.3. Limitations of the Study

There are some limitations of the present study that should be considered. One of the limitations is that the analyzed curriculum is limited with the Turkish science curriculum published in 2018 by the National Ministry of Education. In other words, the data source of the study is the most current national science curriculum according to the time of conducting the study. This curriculum was examined with the content analysis in the scope of the RFN framework. This means that the generated codes and categories were restricted by the RFN framework.

The second limitation is that the context of the study is limited to Turkey. Both the analyzed science curriculum belongs to Turkey and science teachers have been working in

Turkey. This means that the findings of the curriculum analysis and teachers' views are viable for the context of Turkey.

The third limitation of the study is about the participants of the study. Interviews were firstly conducted with 10 science teachers and then gave them the RFN Questionnaire. However, participants cannot represent whole views of the science teachers about the RFN and curriculum because of the limited number. Also, the RFN Questionnaire was given the teachers to answer in their convenient time. Therefore, in which conditions they solve the questionnaire were not controlled. It was assumed that the science teachers solve the questionnaire by paying attention to items.

Another limitation of the study can be that only science teachers were selected as a participant. The aim of selecting science teachers as participants is that they have been using the Turkish science curriculum and giving science lectures. However, in Turkey, primary school teachers also have been using the Turkish science curriculum for their science lectures. Therefore, their views of the RFN and curriculum would enrich the study if they were attended to the study as participants.

The final limitation of the study is the lenses of the researcher. Before starting to analyze data that came from the science curriculum and teachers, inter-rater reliability was considered to and high agreement ratios were found among the researcher and two coders. However, because of the nature of qualitative study, the same data can be analyzed and interpreted in a different way by different researchers. This is because of the researcher's biases, interests, and so on.

5.4. Recommendations for Further Research

In this section, some recommendations for further research are presented. First of all, it is important to examine the inclusion of the RFN in science curricula because it affects how NOS is implemented in science lessons. Thus, it is suggested that recent science-related curricula including primary school science, middle school science, and high school physics, chemistry, and biology education are investigated in the context of the RFN. In this way, it can be seen the progression of NOS in the science-related curricula with more holistically. In other words, it might be made comparison of the inclusion of the RFN among grade levels from primary school to high school. Additionally, how the inclusion of the RFN among curricula changes from past to present can be compared.

Secondly, in the study, some science teachers mentioned the elective science application course that has the curriculum from 5^{th} to 8^{th} grade levels. This curriculum also is needed to be investigated from the RFN perspective to learn the representation of NOS. Moreover, it might be examined how science teachers implement NOS during the elective science application course. Therefore, it can be increased the effectiveness of this course by taking attention of teachers, educators, and so on.

Another recommendation of the study is to increase the number of the participants. In the present study, 10 science teachers were selected as participants by paying attention to diversity and their views of RFN and curriculum were taken. However, increasing number of the participants may result to get more representative findings. In further research, researchers may select the participants not only from science teachers but also from primary school teachers or high school physics, chemistry and biology teachers. In this way, the views of different branches of teachers can be heard about the RFN and science-related curriculum.

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APPENDIX A: THE PERMISSION FROM BOGAZICI UNIVERSITY RESEARCH ETHICS SUB-COMMITTEE

Evrak Tarih ve Sayısı: 05.11.2021-36753

T.C.
BOĞAZİÇİ ÜNİVERSİTESİ REKTÖRLÜĞÜ
Fen Bilimleri ve Mühendislik Alanları İnsan Araştırmaları Etik Kurulu
(FMİNAREK)

Sayı : E-84391427-050.01.04-36753 05.11.2021
Konu : 2021/11 Kayıt no'lu başvurunuz hakkında

Sayın Prof. Dr. Ebru KAYA
Matematik ve Fen Bilimleri Eğitimi Bölüm Başkanlığı - Öğretim Üyesi

"The Inclusion of the Nature of Science in Turkish Science Curriculum" başlıklı projeniz ile Boğaziçi Üniversitesi Fen Bilimleri ve Mühendislik Alanları İnsan Araştırmaları Etik Kurulu (FMİNAREK)'e yaptığınız 2021/11 kayıt numaralı başvuru 01.11.2021 tarihli ve 2021/09 No.lu kurul toplantısında incelenerek etik onay verilmesi uygun bulunmuştur.

Bu karar tüm üyelerin toplantıya on-line olarak katılımıyla ve oybirliği ile alınmıştır. COVID-19 önlemleri nedeniyle üyelerden ıslak imza alınamadığından bu onam mektubu tüm üyeler adına Komisyon Başkanı tarafından e-imzalanmıştır.

Saygılarımızla bilginize sunarız.

Prof. Dr. Tınaz EKİM AŞICI
Başkan

34342 Bebek-İstanbul
Telefon No:0212 287 17 53 Faks No:0212 265 70 06
İnternet Adresi:www.boun.edu.tr
Kep Adresi:bogaziciuniversitesi@hs01.kep.tr
Bilgi için: Nurşen MUNAR
Unvan: Mühendis

APPENDIX B: CONSENT FORM FOR TEACHERS

T.C.
BOĞAZİÇİ ÜNİVERSİTESİ
FEN BİLİMLERİ VE MÜHENDİSLİK ALANLARI
İNSAN ARAŞTIRMALARI ETIK KURULU
KATILIMCI BİLGİ ve ONAM FORMU

Araştırmayı Destekleyen Kurum: Boğaziçi Üniversitesi

Araştırmanın Adı: Türkiye'deki Fen Bilimleri Dersi Öğretim Programındaki Bilimin Doğası İçeriğinin İncelenmesi

Tez Danışmanının Adı: Prof. Dr. Ebru Kaya

E-mail Adresi: **Telefonu:**

Araştırmacının Adı: Gözde Kurt

E-mail Adresi: **Telefonu:**

Sayın öğretmen,

Boğaziçi Üniversitesi Matematik ve Fen Bilimleri Eğitimi bölümünde yüksek lisans yapmaktayım. Bu çalışmanın amacı Türkiye'deki fen bilimleri dersi öğretim programını "Yeniden kavramsallaştırılmış aile benzerliği yaklaşımına dayalı bilimin doğası" kapsamında incelemektir. Ayrıca çalışmayı desteklemesi amacıyla fen bilimleri branşındaki öğretmenlerin öğretim programları ve bilimin doğası ile ilgili görüşlerini belirlemek çalışmanın bir diğer amacıdır. Bu araştırmada bize yardımcı olmanız için siz fen bilimleri öğretmenlerini çalışmama davet ediyorum. Kararınızdan önce araştırma hakkında sizi bilgilendirmek istiyorum. Bu bilgileri okuduktan sonra araştırmaya katılmak isterseniz lütfen bu formu imzalayıp bana ulaştırınız.

Bu araştırmaya katılmayı kabul ettiğiniz takdirde sizinle MEB'in fen bilimleri dersi öğretim programı ve bilimin doğası hakkında görüşlerinizi almak için 40-60 dakika sürecek bir görüşme gerçekleştireceğim. Bu görüşmeler sırasında sizin de izninizle daha sonra analiz etmede kolaylık olması için ses kaydı alınacaktır. Araştırmanın kapsamı dahilinde sizden 70 soruluk "Bilimin Doğası Anketini" de doldurmanız beklenmektedir. Bu anketi doldurmak en çok 20 dakikanızı alacaktır. Bu araştırma bilimsel bir amaçla yapılmaktadır ve katılımcı bilgilerinin gizliliği esas tutulmaktadır. Ses kayıtlarında ve anket formlarında sizin isminiz yerine bir numara kullanılacaktır. Ses kayıtları ve anket formları araştırma süresince araştırmacının kişisel bilgisayarında muhafaza edilip araştırma sona erdiğinde silineceklerdir. Elde edilen veriler kimliğiniz belirtilmeden bilimsel yayın ve sunumlarda kullanılabilir. Bu araştırmaya katılmak tamamen isteğe bağlıdır. Katıldığınız takdirde çalışmanın herhangi bir aşamasında herhangi bir sebep göstermeden onayınızı çekmek hakkına da sahipsiniz. Araştırmadan çekildiğiniz takdirde ses kaydınız ve anket formunuz silinecektir.

Araştırma projesi hakkında ek bilgi almak istediğiniz takdirde lütfen Boğaziçi Üniversitesi Matematik ve Fen Bilimleri Eğitimi bölümü yüksek lisans öğrencisi Gözde Kurt ile temasa geçiniz (e-mail:). Araştırma ile ilgili haklarınız konusunda Boğaziçi Üniversitesi Fen Bilimleri ve Mühendislik Alanları İnsan Araştırmaları Kurulu'na (e-mail:) danışabilirsiniz. Eğer bu araştırmaya katılmayı kabul ediyorsanız, lütfen bu formda size ayrılan yeri doldurup imzalayarak bana geri yollayın.

Ben, ..., yukarıdaki metni okudum ve katılmam istenen çalışmanın kapsamını ve amacını, gönüllü olarak üzerime düşen sorumlulukları tamamen anladım. Çalışma hakkında herhangi bir sorum kalmadı. Bu çalışmayı istediğim zaman ve herhangi bir neden belirtmek zorunda kalmadan bırakabileceğimi ve bıraktığım takdirde herhangi bir olumsuzluk ile karşılaşmayacağımı anladım.

Bu koşullarda söz konusu araştırmaya kendi isteğimle, hiçbir baskı ve zorlama olmaksızın katılmayı kabul ediyorum.

Formun bir örneğini aldım / almak istemiyorum.

Öğretmenin Adı-Soyadı:
İmzası:
Telefon:

E-mail:

Tarih (gün/ay/yıl):...../......./..............

Araştırmacının Adı-Soyadı:

İmzası:

Tarih (gün/ay/yıl):...../......./..............

APPENDIX C: INTERVIEW QUESTIONS FOR TEACHERS (ENGLISH)

Teacher Interview Questions

Personal Questions

1. What is your teaching branch?
2. How many years of teaching experience do you have?
3. Do you work in a public or private school?
4. What is your educational status? (Bachelor's, master's, doctorate, etc.)

Questions about the Nature of Science

5. How would you define science with your own concepts? What comes to mind when you think of science?
6. How would you describe the nature of science with your own concepts? What comes to mind when you think of the nature of science?
7. What do you think the aims and values of science mean? What examples can you give of the aims and values of science?
8. What do scientific methods mean? What examples of scientific methods can you give?
    - Are the scientific methods used by scientists uniform?
    - Do scientific methods differ according to different branches of science? Or are the same scientific methods used in all branches of science?
9. What do scientific practices mean? What examples of scientific practices can you give?
10. What does scientific knowledge mean?
    - Are there different types of scientific knowledge? If so, what are they?
    - Can scientific knowledge change over time? Please explain.
11. Does science have social and institutional aspects? If so, what could it mean? What examples of social and institutional aspects of science can you give?
12. What do you think the social certification and dissemination process in science means? In other words, how do scientists share their works?

13. What does you think scientific ethos mean? In other words, do scientists follow certain norms during their works and in their working processes with other scientists? What might these norms be if they follow?
14. What do you think the social values of science mean? What examples of the social values of science can you give?
15. Do scientists engage in professional activities? If they engage in professional activities, what might they be?
16. What do you think social organizations and interactions mean? Where can scientific knowledge be produced?
17. Is there a relationship between financial systems and science? If so, what kind of relationship is there? Do scientists need money when conducting scientific research?
18. Is there a relationship between the political power structures and science? If so, what kind of relationship is there? Is science affected by political power structures?

Questions about the Curriculum

19. Do you use the curriculum in your science lessons? To what extent and for what purposes do you use it?
20. Does the science curriculum meet your expectations? Do you think there is any deficiency? What are your suggestions regarding these deficiencies?
21. Do you teach your students the nature of science in your science lessons? How?
22. What are your suggestions about teaching and including the nature of science in lessons?
23. Are there any emphases on the nature of science in the science curriculum? If any, which components were highlighted?
24. Should the nature of science be included in the science curriculum? How can it be included? What are your suggestions?
25. "In the process of discovering nature and understanding the relationship between human-environment, adopting scientific process skills and scientific research approach and producing solutions to the problems encountered in these fields" (MEB, 2018a, p.9) is one of the main purposes of the Science Curriculum. Do you think this purpose is related to the nature of science? If so, which component or components of the nature of science do you think has to do with it? Please explain.

26. “To help understand how scientific knowledge is created by scientists, the processes that this knowledge goes through and how it is used in new research” (MEB, 2018a, p.9) is one of the main purposes of the Science Curriculum. Do you think this purpose is related to the nature of science? If so, which component or components of the nature of science do you think has to do with it? Please explain.
27. “To ensure the adoption of universal moral values, national and cultural values and scientific ethical principles” (MEB, 2018a, p.9) is one of the main purposes of the Science Curriculum. Do you think this purpose is related to the nature of science? If so, which component or components of the nature of science do you think has to do with it? Please explain.
28. “Presents the observation results of a plant's life cycle. It is expected to monitor the development of a plant for a certain period of time and to record the observation results” (MEB, 2018a, p.18). Do you think that this objective in the Science Curriculum is related to the nature of science? If so, which component or components of the nature of science do you think has to do with it? Please explain.
29. “Discusses the importance of conscious and efficient use of electrical energy in terms of family and national economy. The studies carried out by official institutions and non-governmental organizations in our country on energy efficiency and the things to be done in terms of electrical energy use are stated” (MEB, 2018a, p.54). Do you think that this objective in the Science Curriculum is related to the nature of science? If so, which component or components of the nature of science do you think has to do with it? Please explain.

APPENDIX C: INTERVIEW QUESTIONS FOR TEACHERS (TURKISH)

Öğretmen Görüşme Soruları

Kişisel Sorular

1. Öğretmenlik branşınız nedir?
2. Kaç senelik öğretmenlik tecrübeniz var?
3. Devlet okulunda mı, özel okulda mı çalışıyorsunuz?
4. Eğitim durumunuz nedir? (Lisans, yüksek lisans, doktora vb.)

Bilimin Doğası İle İlgili Sorular

5. Bilimi kendi kavramlarınız ile nasıl tanımlarsınız? Bilim deyince aklınıza ne geliyor?
6. Bilimin doğasını kendi kavramlarınız ile nasıl tanımlarsınız? Bilimin doğası deyince aklınıza ne geliyor?
7. Bilimin amaçları ve değerleri sizce ne anlama geliyor? Bilimin amaç ve değerlerine hangi örnekleri verebilirsiniz?
8. Bilimsel yöntemler ne demektir? Bilimsel yöntemlere hangi örnekleri verebilirsiniz?

- Bilim insanlarının kullandığı bilimsel yöntemler tek tip midir?
- Bilimsel yöntemler farklı bilim dallarına göre değişiklik gösterir mi? Yoksa bütün bilim dallarında aynı bilimsel yöntemler mi kullanılır?

9. Bilimsel pratikler ne demektir? Bilimsel pratiklere hangi örnekleri verebilirsiniz?
10. Bilimsel bilgi ne demektir?

- Bilimsel bilginin farklı türleri var mıdır? Varsa nelerdir?
- Bilimsel bilgi zamanla değişebilir mi? Açıklayınız.

11. Bilimin sosyal ve kurumsal yönleri var mıdır? Varsa ne anlama geliyor olabilir? Bilimin sosyal ve kurumsal yönlerine hangi örnekleri verebilirsiniz?
12. Bilimdeki sosyal kabul ve yayılım süreci sizce ne anlama geliyor? Diğer bir deyişle bilim insanları çalışmalarını nasıl paylaşırlar?

13. Bilimsel değerler sizce ne anlama geliyor? Diğer bir deyişle bilim insanları çalışmaları süresince ve diğer bilim insanları ile olan çalışma süreçlerinde belirli normlar takip ederler mi? Takip ederlerse bu normlar neler olabilir?
14. Bilimin sosyal değerleri sizce ne anlama geliyor? Bilimin sosyal değerlerine hangi örnekleri verebilirsiniz?
15. Bilim insanları profesyonel aktivitelerde bulunurlar mı? Eğer profesyonel aktivitelerde bulunurlarsa bunlar neler olabilir?
16. Sosyal kurumlar ve etkileşimler sizce ne anlama geliyor? Bilimsel bilgi nerelerde üretilebilir?
17. Finansal sistemler ve bilim arasında ilişki var mıdır? Varsa nasıl bir ilişki vardır? Bilimsel araştırmalar yapılırken bilim insanları paraya ihtiyaç duyarlar mı?
18. Politik güç yapısı ve bilim arasında ilişki var mıdır? Varsa nasıl bir ilişki vardır? Bilim politik güç yapılarından etkilenir mi?

Öğretim Programına Yönelik Sorular

19. Fen bilimleri derslerinizde öğretim programını kullanıyor musunuz? Kullanıyorsanız ne ölçüde ve hangi amaçlarla kullanıyorsunuz?
20. Fen bilimleri dersi öğretim programı beklentilerinizi karşılıyor mu? Herhangi bir eksikliği olduğunu düşünüyor musunuz? Bu eksikliklerle ilgili önerileriniz nelerdir?
21. Fen bilimleri dersinde öğrencilerinize bilimin doğasını öğretiyor musunuz? Nasıl?
22. Bilimin doğasının derslerde öğretilmesi ve derslere dahil edilmesi konusunda önerileriniz nelerdir?
23. Fen bilimleri dersi öğretim programında bilimin doğasına yönelik vurgulamalar var mıdır? Varsa hangi bileşenleri vurgulanmıştır?
24. Fen bilimleri dersi öğretim programında bilimin doğasına yer verilmeli midir? Nasıl yer verilebilir? Önerileriniz nelerdir?
25. "Doğanın keşfedilmesi ve insan-çevre arasındaki ilişkinin anlaşılması sürecinde, bilimsel süreç becerileri ve bilimsel araştırma yaklaşımını benimseyip bu alanlarda karşılaşılan sorunlara çözüm üretmek" (MEB, 2018a, p.9) Fen Bilimleri Dersi Öğretim Programında yer alan temel amaçlardan biridir. Bu amacın bilimin doğası ile ilişkisi olduğunu düşünüyor musunuz? Düşünüyorsanız bilimin doğasının hangi bileşeni ya da bileşenleriyle ilişkisi olduğunu düşünüyorsunuz? Açıklayınız.

26. "Bilim insanlarınca bilimsel bilginin nasıl oluşturulduğunu, oluşturulan bu bilginin geçtiği süreçleri ve yeni araştırmalarda nasıl kullanıldığını anlamaya yardımcı olmak" (MEB, 2018a, p.9) Fen Bilimleri Dersi Öğretim Programında yer alan temel amaçlardan biridir. Bu amacın bilimin doğası ile ilişkisi olduğunu düşünüyor musunuz? Düşünüyorsanız bilimin doğasının hangi bileşeni ya da bileşenleriyle ilişkisi olduğunu düşünüyorsunuz? Açıklayınız.
27. "Evrensel ahlak değerleri, millî ve kültürel değerler ile bilimsel etik ilkelerinin benimsenmesini sağlamak" (MEB, 2018a, p.9) Fen Bilimleri Dersi Öğretim Programında yer alan temel amaçlardan biridir. Bu amacın bilimin doğası ile ilişkisi olduğunu düşünüyor musunuz? Düşünüyorsanız bilimin doğasının hangi bileşeni ya da bileşenleriyle ilişkisi olduğunu düşünüyorsunuz? Açıklayınız.
28. "Bir bitkinin yaşam döngüsüne ait gözlem sonuçlarını sunar. *Bir bitkinin belirli bir süre boyunca gelişiminin izlenmesi ve gözlem sonuçlarının kaydedilmesi beklenir"* (MEB, 2018a, p.18). Fen Bilimleri Dersi Öğretim Programında yer alan bu kazanımın bilimin doğası ile ilişkisi olduğunu düşünüyor musunuz? Düşünüyorsanız bilimin doğasının hangi bileşeni ya da bileşenleriyle ilişkisi olduğunu düşünüyorsunuz? Açıklayınız.
29. "Elektrik enerjisinin bilinçli ve tasarruflu kullanılmasının aile ve ülke ekonomisi bakımından önemini tartışır. *Enerji verimliliği konusunda ülkemizdeki resmî kurumlar ve sivil toplum kuruluşları tarafından yapılan çalışmalar ve elektrik enerjisi kullanımı bakımından yapılması gerekenler belirtilir*" (MEB, 2018a, p.54). Fen Bilimleri Dersi Öğretim Programında yer alan bu kazanımın bilimin doğası ile ilişkisi olduğunu düşünüyor musunuz? Düşünüyorsanız bilimin doğasının hangi bileşeni ya da bileşenleriyle ilişkisi olduğunu düşünüyorsunuz? Açıklayınız.

APPENDIX D: RFN QUESTIONNAIRE

RFN QUESTIONNAIRE (ENGLISH)

Directions: In this questionnaire, there are 70 statements about the nature of science. Please read the following statements and then select the alternative that best describes your position on the statement. The alternatives are "Totally Disagree", "Disagree", "Not Sure", "Agree" and "Totally Agree".

	Totally Disagree	**Disagree**	**Not Sure**	**Agree**	**Totally Agree**
1. Science lessons should include financial (economical) aspects of science.					
2. Epistemic, cognitive and cultural values of science cannot be distinctly distinguished from each other.					
3. Scientific knowledge does not change.					
4. Scientists review and assess each other's work.					
5. The power of experimentation comes from testing a scientific hypothesis many times by scientists.					
6. Concept maps can be an effective way of teaching classification as scientific practice.					
7. Science takes place in institutions such as universities and research centres.					
8. All scientific disciplines such as physics, biology and chemistry use the same scientific method.					
9. Science is a social system.					
10. Scientific progress occurs when ideas are evaluated and revised.					
11. Each branch of science has a different nature.					
12. Students should determine the methods of their science investigations themselves.					
13. Politics does not influence science.					

14. Scientists should respect the environment.					
15. Analysis and interpretation of data are components of scientific practices.					
16. Theories and laws are forms of scientific knowledge but models are not.					
17. Teaching scientific aims and values of science is likely to improve students' understanding of science.					
18. Scientists don't have to share their research with society.					
19. Scientists build and use models to understand complex scientific phenomena.					
20. The diversity of scientists solving a problem together means less biased results.					
21. Students should understand that theories are a collection of models.					
22. There is no step by step order to doing science.					
23. All branches of science use observations.					
24. Diversity of methods contributes to scientific understanding.					
25. All hypothesis testing is manipulative.					
26. Some branches of science do not use representations.					
27. Educating students about scientific aims and values improves scientific literacy.					
28. Scientists have to use different methods to produce enough evidence so that they can solve problems.					
29. Students should be encouraged to collaborate with their peers in science lessons because scientists collaborate with other scientists when doing research.					
30. Scientific knowledge consists of a coherent set of ideas.					
31. The curriculum should stress that theories in chemistry and physics are the same.					
32. Scientists need money to do research.					
33. Classification helps scientists explain and predict phenomena.					
34. All scientific disciplines such as physics, biology and chemistry produce values that can contribute to society.					

35. It does not make a difference to students' learning of science when they participate in discussions about experimental data.					
36. The gender of scientists influences how they do science.					
37. There is a universal scientific method that all scientists use all over the world.					
38. Scientific experiments follow a certain set of procedures.					
39. Intellectual honesty in science does not have to be taught in science lessons.					
40. Scientists should change their minds when they realise that their ideas are not supported by evidence.					
41. Policies of governments affect the growth of scientific knowledge.					
42. Students should sometimes have the choice to design methods for their investigations.					
43. Laws are theories that are confirmed.					
44. Scientific models are tools to represent the real world.					
45. Some scientists earn more money than others, causing tension between scientists.					
46. Scientific facts are not affected by bias and individual subjective prejudices of scientists.					
47. Science teaching should specify that laws are certain and unchangeable.					
48. Race and ethnicity of scientists have nothing to do with science.					
49. Changing variables is a fundamental requirement for a scientific study.					
50. Theories, laws and models work together to produce scientific knowledge.					
51. Teaching epistemic, cognitive, social and cultural values should be the core components of the science curriculum.					
52. Different branches of science like physics, biology and chemistry have the same practices.					
53. Scientists write papers in academic journals.					
54. There are different kinds of theories. Some are accepted,					

others are still debated.					
55. Science curriculum should not only cover scientific knowledge, but also the social and cultural aspects of science.					
56. There is no relationship between scientific facts and values.					
57. Scientists from all branches of science validate scientific knowledge by evaluating each other’s ideas.					
58. Scientists participate in conferences to share their research with other scientists.					
59. Understanding scientific methodology can help students distinguish between science and non-science.					
60. All scientific disciplines such as physics, biology and chemistry require constructing hypotheses.					
61. There are standards for evaluating the quality of scientific work.					
62. Internalizing scientific aims and values enables students to understand scientific knowledge.					
63. Models can help scientists to explain and predict phenomena.					
64. Scientific practices produce knowledge and are not influenced by cultural factors.					
65. Students should understand that scientists need to have social values such as honesty.					
66. Laws are more verifiable scientific knowledge than theories.					
67. There are social hierarchies among science teams and these can change.					
68. It’s not necessary for students to understand how knowledge develops in science.					
69. Scientific aims and values affect scientists’ choice of methods in their investigations.					
70. Scientists socially interact with other scientists while doing research.					

APPENDIX D: RFN QUESTIONNAIRE

BİLİMİN DOĞASI ANKETİ (TURKISH)

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 ayrılamaz.					
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.					
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 arttırır.					
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 anlamalıdırlar.					
22. Bilim yaparken adım adım takip edilecek bir sıralama yoktur.					
23. Gözlem tüm bilim dallarında kullanılır.					
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 okuryazarlığı 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.					
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.					
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.					

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APPENDIX F: TURKISH VERSION OF THE SCIENCE TEACHER QUOTATIONS FROM INTERVIEWS

1. Bilimi nasıl tanımlarım? Aslında insanların ihtiyacından çoğunlukla doğmuş olduğunu düşünüyorum. Bununla beraber meraktan, ihtiyaçlardan yaratıcı bir şeyler oluşturma adına genel olarak söyleyebilirim.

2. Yani bilimin doğası denilen şey bilimin doğasındaki yani bilime özgü özellikler herhalde. Nasıl? Kavramsal olaraksa yani bilimin doğası değişkenlik gösterir. Yine aslında benzer şeyleri belki konuşacağım. Kanıta, veriye dayalı, işte deneye, gözleme dayalı elde edilen bilgilerdir.

3. Bilimin amacı bence insanlığa hizmet olmalı her şeyden önce. Şu an yaşadığımız pandemi döneminde de bilimin ne denli hizmet ettiğini hep beraber görüyoruz. Şu an aşılar olmasaydı zaten gerçekten şu an hayatta olmayabilirdik. Bilimin amacı bence çok büyük.

4. Bilimsel yöntemler bilimsel bilgiye ulaşma yolları aslında. Bunlar modern bilimde deney, gözlem gibi yöntemler.

5. Farklılık gösterir diye düşünüyorum. Şimdi bu konuyla ilgili çok büyük böyle alan hakimiyeti olan bir insan değilim. Ama bir mantık kurduğumuzda evet belli bilimsel yöntemler vardır. İnsanlar araştırmaları doğrultusunda da bu bilimsel yöntemlerden kendileri için en doğru olanı seçerler. Ama tabii ki hepsinin izleyeceği yol genel hatlarıyla aynı olmalıdır diye düşünüyorum. Önce bir fikir oluşturma sonra onu gözlemleme, araştırma yapma. Sonra onu bir şeye dayanaklandırma şeklinde ilerlemelidir diye düşünüyorum.

6. Bilimsel pratiklerde şeyler mesela bilgiyi hani daha doğrusu... Bilgi denir mi? Bilgiyi araştırıyoruz veya bir deney yapıyoruz. Bunun sonucunda bize bir veri geliyor. Bu veriyi biz ne yapıyoruz işte birileriyle tartışıyoruz veya işte onlarla ilgili raporlar sunuyoruz.

7. Bilimsel bilgi aslında belli otoritelerce yani hani bu bilimle ilgilenen birtakım kurumlar tarafından hakemler aracılığıyla onaylanmış çalışmalar sonucunda elde ettiğimiz bilgiler.

8. Bilimsel bilginin farklı türleri. Yani aklımda bir şey canlanmadı şu an ya. Üniversitede okuyalı baya olmuş evet unutmuşuz.

9. Ya zamanla tabii ki değişir. En kolay şeyi fizikte gösterebilirim. Fizikte çok uzun bir süre hayat mekanik üstüne kuruluydu. Yani mekanik başlığı adı altında topladığımız fiziksel bilgiye sahiptik. Ama daha sonra bunun üstüne gelen rölativite mesela bir sürü bildiğimiz bilginin değişmesine sebep oldu.

10. Bilimin sosyal yönü tabii ki de var. Şöyle bilimin sosyal yönü var hatta: En basitinden herkesin de aklına geleceği gibi konferanslar. Mesela bilim insanları çalışmalar yapıyorlar. Onları ne yapıyorlar? Konferanslarda sunuyorlar. Bildiriler yayınlıyorlar.

11. Araştırma yapan insanların maddi yönden desteklenmesi gerekiyor çünkü araştırma yapmak maliyetli bir şey, zaman gerektiren bir şey. Bunun bir yerden fonlanması gerekiyor. Bu fonun da bir kurum tarafından büyük oranda kurumlar tarafından karşılanması gerekiyor. Bu açılardan kurumsal yönü olabilir.

12. Tabii ki de bilim insanları yaptıkları bir şeyi paylaşmak ve diğer bilim insanları ile tabii ki de paylaşmak zorundalar aslında çünkü tek başlarına ürettikleri bir şey onay almamış oluyor tabii ki de. Ve üstüne bir şey eklenmemiş oluyor veya değerlendirilmemiş oluyor. O yüzden kesinlikle tabii ki de şey yapılıyor bilimsel bilgi veya işte bu çalışmalar toplulukla paylaşılıyor. Bu şekilde aslında güvenirliği ve geçerliği artıyor yani.

13. Yani nasıl paylaşıyorlar? Bir kere paylaşmaları için bir zemin olmalı. Şu an mesela ortak bir bilimin amacı olması da bu. Latince biliyorsunuz bilim dilinde özellikle fende ortak kullanılan bir dil gibi.

14. Kendi yorumumu söylemem gerekirse olması gerekiyor değerin tabii. Ama şunu da tahmin edebiliyorum ya da en azından olabileceğini düşünüyorum: Çok ahlaki, etik

durumlara bağlı kalındığında bir yere kadar ilerleme kaydedileceğini. Her bilginin bu şekilde ya da her bilimsel verinin bu şekilde ulaşılamayacağını düşünüyorum. Ama bir yanda da tabii çok da değerleri kaybetmemeli bir yanı var.

15. Yani bilimsel değerler tabii bir kere veri setinin açık hale gelmesi, şeffaf olması. Araştırma yöntemlerini ayrıntılı olarak verebilmek, sunabilmek, açıklayabilmek. Ondan sonra elde ettiğin dolayısıyla veri setinin şeffaf olabilmesi gerektiğinde. Ondan sonra tabii doğruluk işte mesela şey konusunda mesela katılımcılar konusunda. Katılımcıların bilgilerini doğru verebilmek.

16. Bilimin sosyal değerleri... Bilimin sosyal değerleri deyince biraz daha toplumla sanırım olan ilişkisi ve etkisi ne diye aklıma geliyor şu anda.

17. Bilimin sosyal değerleri... Hiç düşünmedim. Yani bilimin sosyal değerleri neler olabilir? İnsanların hayatını kolaylaştıran her şey diyebilirim çünkü... bilimin sosyal yaşantıda ne gibi faydası olabilir? Sosyal yaşantımızda şu an zaten zaman çok değerli. Herkesin her şeyi daha kolay, daha hızlı yapabilmesini sağlayan bir şey bilim diye düşünüyorum.

18. Profesyonel aktivitelerde evet bulunuyorlar. Zaten bu bildiri, konferanslar felan da amacı birazcık da profesyonel bir çalışma imkanı, kişilerin bir araya gelmesi. Bu kişiler bir araya geldikleri zaman yaptıkları çalışmalardan bahsediyorlar.

19. Hangi aktivite derseniz. Yani golf oynamak bile bir bilim insanı için bence çok çabuk öğrenilebilir veya çok kolay kavranılabilir. Çok kolay başarılı noktaya ulaşılabilir bir aktivite olabilir.

20. Etkileşim mutlaka vardır. Hani mesela önce söylediğim gibi uzay araştırmalarında ilk başta NASA vardı dünyada. Ve hani ondan takiben TESLA mesela kendine özel olarak uzay araştırmaları gerçekleştirmeye başladı. Ve hani mutlaka etkileşim vardır. Olmasa zaten bilim gelişemez diye düşünüyorum.

21. Bilimsel bilgi her yerde üretilebilir. Yani bir kuruma, bir politikanın içine veya herhangi sadece belli bir kesime koymak gereksiz. Bunun tabii bir eğitimden

geçmek onu kolaylaştırabilir. Ama bilimsel bilginin üretildiği yer bence hani mekandan sınırsız yani bağımsızdır.

22. Şimdi finansal sistemler deyince anladığım kadarıyla bu işin maddi boyutu ve bunun bu anlamda ona çalışma sağlanması için uygun ortamların ya da olanakların sağlanması durumu geliyor. Şimdi bir bilginin ortaya çıkması için tabii ki bunun için finansal bir alt yapıya gerek olmayabilir. Ama onun ispatlanması, araştırılması, gözlem yapılması ve bir şeye dayanaklandırılması için ve herkes tarafından kabul edilmesi için yapılması gereken araştırmalarda mutlaka bir finansörlük gerekiyor diye düşünüyorum.

23. Keşke olmasa ama finansal olarak desteklenmediği sürece bilimsel anlamda ilerleme kaydedemiyorsun ne yazık ki. Çünkü herhangi bir deneyi yapmak bazen az önce de konuştuğumuz gibi yıllar sürebiliyor. İnsanların kendi hayatlarını da devam ettirmesi gerekiyor ya da bilimsel çalışmalar malzeme, altyapı gerektiriyor. Yeri geliyor bir malzemenin, işte atıyorum Cern'den bir çarpıştırıcının hızı milyon dolarları bulabiliyor. O yüzden mali olarak fonlanmak maddi olarak çok büyük güçler gerektiriyor. Maalesef çok alakalılar.

24. Kesinlikle politik olarak da vardır. Devletler kendi çıkarlarına hizmet edecek olan çalışmalara daha çok destek verebilirler veya bazılarını engellerler. Bazı çalışmanın yapılmasına izin vermeyebilirler.

25. Öğretim programını kullanıyor muyum derken yani ne kullanıyorum diyebiliriz, ne kullanmıyorum diyebiliriz. Tamamen bağımsız değilim. Bağımsız değilim derken kopuk değilim. Ama tabii ki yüzde yüz kullanıyor musunuz derseniz hayır kullanmıyorum.

26. Yani şöyle kazanımları zaten öğretim programı kazanımları içeriyor ağırlıklı olarak. Konular var öğretim programında. Bir de başlangıç kısmı filan var sadece. Orada mesela değindiği konular olabiliyor. Ama o başlangıç yani içerik, başlangıç kısmı bazen kazanımlara çok fazla yansımayabiliyor. Biz yıllık planda kazanımları kullanmak zorundayız. Hatta ders defterine de yazmak zorundayız. O nedenle o kazanımları merkeze koyarak tabii derslerimi işliyorum.

27. Bir de bilginin değişebilirliğini çok fazla şey yapmıştım. Mesela önceden hangisiydi şu an tam hatırlayamadım ama… Aristo'nun bir düşüncesi miydi ya? Eski bir düşünceyi veriyorum. Böyleymiş diyorum. Ama yıllar sonra Galileo gelmiş şöyle şöyle demiş ve bunun, yıllar boyunca kabul edilen bir şeyin değiştiğini göstermiş. Mesela bunları da kullanmıştım dersimde. Demek yıllarca nasıl kabul edilmiş diye çocuklar şaşırmışlardı. Bilginin bir anda alt üst değişebileceğini görmüştü burada.

28. Bir de şey öğretim programına dahil edilmesi yöntemleri çok fazla. Şey de değil sadece deney dışında da dahil edilebilir. Bilim insanlarının hayatı anlatılıyor sadece. Ama mesela bilim insanları bunu nasıl yaptı? İşte o bilgilere nasıl ulaştı? Hangi bilim insanının hangi... Bir tek atomun tarihçesinde var. O yani.

29. Bence öğretim programında kazanım olarak direkt geçiyor mu bilmiyorum ama işte kazanım olarak geçebilir çünkü bizim yol haritamız direkt öğretim programı. Öğretim programında yer alırsa ve bu hizmet içi eğitimlerde bunun eğitimi öğretmenlere verilirse biraz daha faydalı olacağını düşünüyorum. Çünkü bilimin doğasından habersiz insanların bilimin doğasını öğretmesi çok zor. Onun için önce bir farkındalık oluşturduktan sonra bence olabilir.

30. Sanırım en fazla deney yapmakla alakalı şeyler var. Şunu şunu deney yaparak şey yapar tarzı kazanımlar oluyor. Bunun haricinde hatırladığım kadarıyla gözlem vardır. Imm başka aklıma bir şey gelmiyor yani şu an. Kazanımları düşündüğümde, programı düşündüğümde.

31. Bilimin amacı belki yani biraz. Ama çok fazla değil yani bilimin amacından da çok bahsedilmiyor yani. Bilimin değeri, önemi yani öyle bahsedilmiyor. Zaten toplumsal, politik anlamları falan hiç.

32. Verilmeli. Bu da az önce bahsettiğim net olarak vurgulanmamış gizli bir vurgu belki olabilir. Ama bunu onların fark etmesi... Evet bilimin doğası çok geniş. Tek bir görsel değil de onların biraz daha hayal gücünü destekleyebilecek bir konu başlığı olabilir. Ve bu tek fen bilgisi ya da fen bilimleri fark etmez zaten bir tek bir öğretmenle değil de bu konuyu destekleyebilecek, belki de bu noktada hayal

güçlerine, akıllarındaki farklı noktalarla eşleşen veya kesişen sorularını cevaplama noktasında farklı alanlarla ilerletilmesi gereken bir ders başlığı bile olabilir.

33. Yer verilmelidir çünkü bilimin bir parçasını düşünün yani bilimi bir yapboz gibi düşünürsek bir parçası eksikse hiçbir zaman tamamlanmamış olur. Onun için kesinlikle bilimin doğasına yer verilmeli. Nasıl? Mesela kazanımlara entegre edilerek yer verilebilir.

34. Var. Yani bu konuyla ilgili ne çıksa karşıma var diyeceğim. Zaten dediğim gibi içindeki bir konu. Zaten iç içe durumlar. Ama neyle ilgisi var? Yani başka bir canlı... Bilimin doğası kısmı nasıl? Onu düşünerek bulamıyorum ama cevap olarak.

35. Katılımcı 1: Bu scientific pratices olayına giriyor. Yani gözlem yapmak, kaydetmek, işte sunmak mesela belki de. Sonuçları sunmak kavramı burada önemli olabilir.
Researcher: Sunmayı neye koyarsın? Bilimsel pratiklere mi?
Katılımcı 1: Sunmayı aslında biraz sanki sosyale giriyor gibi geldi burada çünkü diğerleri daha çok bilimsel şeyler, metotlara giriyor. İşte pratikelere giriyor. Ama bu sunma kısmı biraz hafif kalmış orada kullanığı kelime. Ama yine de bir anlam katıyor orada sunmak deyince. Hani paylaşmak gibi.

36. Tabii yine birbirlerine bağlı noktalar. Çok ayıramıyorum. Yine aynı cevapları da vermek istemediğim için yine aynı düşünce yapısında ilerlediğimi söyleyebilirim.