FIFTH-GRADE STUDENTS' ATTITUDES TOWARDS SCIENCE AND THEIR UNDERSTANDING OF ITS SOCIAL-INSTITUTIONAL ASPECTS

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DECLARATION OF ORIGINALITY

I, Melike Alayoğlu, certify that

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ABSTRACT

Fifth-Grade Students' Attitudes Towards Science and Their Understanding of Its Social-Institutional Aspects

The present study is based on the Reconceptualized Family Resemblance Approach to Nature of Science (RFN) (Erduran & Dagger, 2014) which explains science as cognitive, epistemic, and social-institutional system. Kaya and Erduran (2016) analyzed Turkish science curricula and found that social context of science is underemphasized. Thus, this study investigated the impact of teaching science as a social institutional system on 5th grade students' understanding of social dimension of science and their attitudes towards science .Using pre-test post-test quasi-experimental research design, Science-Institutional Questionnaire (SIQ) and Scientific Attitude Inventory (SAI) were administered to the experimental (n=19) and control (n=23) groups. The sample was randomly selected from 5th grade students of a public school in İstanbul. Throughout the intervention (4 weeks), the experimental group was exposed to the science lessons enriched with the social-institutional aspects of science while the control group was taught with traditionally designed science lessons in the unit "The Earth, Sun and the Moon". Results of ANCOVA revealed that there were statistically significant differences between the study groups in favor of students in the experimental group on both study variables. In other words, integration of the social-institutional aspects of science into science lessons enhanced students' understanding of social dimension of science as well as their positive attitudes toward science. This study has a potential to contribute to the literature on NOS in science education and provide science teachers a resource.

ÖZET

Beşinci Sınıf Öğrencilerinin Bilimin Sosyal ve Kurumsal Yönlerine İlişkin Anlayışları ve Bilime Karşı Tutumları

Bilimin doğasını (NOS) açıklayan Yeniden Kavramsallaştırılmış Aile Benzerliği Yaklaşımı (RFN) (Erduran & Dagher, 2014) bu çalışmanın teorik altyapısını oluşturmaktadır. Kaya ve Erduran (2016) yaptıkları çalışmada Türk fen müfredatında bilimin sosyal bağlamının yeterince önemsenmediğini bulmuşlardır. Bu sonuç, Türk öğrencilerin bilimin sosyal yönleri konusunda sınırlı bir anlayışa sahip olabileceklerini göstermektedir. Bu sebeple, çalışmanın amacı bilimin sosyal ve kurumsal bir sistem olarak öğretildiği fen derslerinin, 5.sınıf öğrencilerinin bilimin sosyal-kurumsal yönüne ilişkin anlayışlarını ve bilime karşı tutumlarını nasıl etkilediğini incelemektir. Araştırmada Sosyal Kurumsal Test (SIQ) ve Bilimsel Tutum Ölçeği (SAI) öntest-sontest olarak uygulanmış ve yarı deneysel desen kullanılmıştır. Araştırmanın deney (n=19) ve kontrol (n=23) grupları uygun örnekleme kullanılarak İstanbul'da bir devlet okulundan seçilmiştir. Araştırmanın deney grubunda Dünya, Güneş ve Ay ünitesi bilimin sosyal ve kurumsal yönü vurgulanarak, kontrol grubunda ise vurgulanmayarak işlenmiştir. ANCOVA sonuçları her iki değişkende deney grubundaki öğrenciler lehine gruplar arasında istatistiksel olarak anlamlı farklar olduğunu ortaya koymuştur. Başka bir deyişle, bilimin sosyal-kurumsal yönlerinin fen derslerine entegrasyonu, öğrencilerin bilime karşı tutumlarını ve bilimin sosyal-kurumsal yönlerine ilişkin anlayışlarını geliştirmiştir. Bu çalışma, fen eğitiminde NOS literatürüne katkıda bulunma ve fen eğitimcilerine bir kaynak sağlama potansiyeline sahiptir.

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CHAPTER 1

INTRODUCTION

Nature of science (NOS) has become an important area of research in science education in the last few decades (Erduran & Dagher, 2014). There are diverse definitions of NOS in the literature. The most cited and the most influential authors in the field defined NOS as: "Typically, NOS refers to the epistemology and sociology of science, science as a way of knowing, or the values and beliefs inherent to scientific knowledge and its development" (Lederman, N. G., Abd-El Khalick, F., Bell, R. L., & Schwartz, R. S. 2002, p.498).

It is important to teach nature of science (NOS) in science classes because we live in a society in which we have to make judgments about scientific claims. Students should be able to evaluate scientific knowledge and make informed decisions about socio-scientific issues. Also, the ability to distinguish science from pseudoscience requires understanding the nature of science. Driver, Leach, Millar and Scott (1996) provided five arguments as an answer of question why understanding NOS is important. One of the arguments is the utilitarian view that stated the understanding of NOS is necessary to have an idea about how scientific enterprises work. It is also necessary to manage technological. According to Driver et al., (1996)'s democratic view, students should understand NOS "to make a sense of socio-scientific issues and participate in the decision–making process" (p.18). Also the cultural view stated that understanding of NOS in necessary "in order to appreciate science as a major element of contemporary culture" (p.19). According to fifth argument, learning NOS helps students learn science subject matters.

There are various understandings of NOS in the literature (Irzik & Nola, 2014; Lederman et al., 2002; Matthews, 2012). One of them is “consensus view”. During the last two decades, contemporary account of NOS so-called “consensus view” has been adopted in the science education literature (Abd-El Khalick, 2012; Lederman et al., 2002; McComas, 1998). The group defended seven elements of NOS. These are tentativeness, observation, inference and theoretical entities in science, the theory-laden nature of scientific knowledge, the creative and imaginative nature of scientific knowledge, social and cultural embeddedness, scientific theories and laws, myhts of scientific method (Lederman et al., 2002). These elements describe mostly the nature of scientific knowledge.

An additional perspective to characterize NOS is Whole Science proposed by Allchin (2011). His perspective does not exclude essential elements of science. Instead, it includes many items such as motivation, role of funding, peer review, cognitive biases that are absent in “consensus view” because scientific work includes social interactions besides cognitive methods (Erduran & Dagher, 2014; Longino, 1990; Shapin, 1996).

Science is more than the seven elements of Lederman’s “consensus view”. For this reason Matthew (2012) broadened the nature of science beyond consensus view by changing focus from NOS to Feature of Science (FOS). He suggested additional features to science. These are idealization, modeling, experimentation, mathematization, technology, worldviews, religion, feminism, constructivism and realism (Matthew, 2012). However, Matthew does not give reasons for why he selected these specific features and not others (Erduran & Dagher, 2014). In addition, these additional features are disparate ideas from various discipline, some of them explain epistemological aspects of science (explanation) while others are related to philosophical point of views (feminism, constructivism) (Erduran & Dagher, 2014).

More recently, Irzik and Nola (2011a, 2014) developed Family Resemblance Approach to characterize science based on philosophical notion of family resemblance on Wittgenstein's work. This scheme is an alternative to the consensus view because of its more comprehensive and systematic structure (Irzik & Nola, 2014). The fundamental principle of this framework is that there are characteristics common to all sciences some are specific for a particular sciences. The family resemblance model of nature of science conceptualizes science in terms of a cognitive-epistemic and a social-institutional system. Science as a cognitive-epistemic system includes process of inquiry, aims and values, methods and methodological rules, scientific knowledge. On the other hand, science as a social-institutional system includes professional activities, scientific ethos, social certification and dissemination of scientific knowledge and social values.
Erduran and Dagher reconceptualized Irzik and Nola's FRA to use it in science education (2014). The terminology of "Reconceptualized FRA-to-NOS" (RFN) is used to differentiate the Erduran and Dagher' FRA version from the various accounts of the family resemblance idea (Kaya& Erduran, 2016a).RFN provides a holistic and more comprehensive image of science. It is also pedagogically useful. The original FRA model has been modified by Erduran and Dagher (2014) to include three additional categories to science as a social and institutional system. These are: financial systems, political power structures and social organizations and interactions. These aspects of science are not explicit in Irzik and Nola's (2014) framework.

There are several approaches in science education literature based on the idea that science interacts with society. For instance, Science-Technology and Society (STS) and Socio-scientific issues (SSI) are related to social context of science. STS education emphasizes the interrelationships among science, technology, and society (Nichols & Zeidler, 2009). However, it does not consider the ethical dimension of science. On the other hand, socio-scientific issues (SSI) and social-institutional aspects of science can be confused with each other because of their name similarity but they are different approaches in their nature.

Socio-scientific (SSI) issues refer to "use of scientific topics that require students to engage in dialogue, discussion, and debate" (Nichols & Zeidler, 2009). These topics generally include disagreement on a scientific question and lack exact solution (Kolstø, Bungum, Arnesen, Isnes, Kristensen, Mathiassen, Mestad, Quale, Tonning, & Ulvik, 2006).For instance, genetics, animals, energy sources and artificial intelligence can be considered as socio-scientific issues. The socio-scientific issues (SSI) is a kind of teaching pedagogy that improves scientific literacy and helps students differentiate science from pseudoscience (Driver, Newton, & Osborne, 2000; Sadler, 2009). Also, students as future citizens can make more informed decisions about socially controversial issues through SSI framework (Duschl, 2007). SSI involves moral reasoning, evaluation of ethical concerns as well as evidence-based reasoning. Besides, it requires understanding of scientific information at a certain level (Sadler, 2004; Zeidler, 2003).

NOS and socio-scientific issues are highly interrelated in spite of the fact that they are distinct approaches. Many studies have stated the importance of socio-scientific issues in enhancing students' NOS understanding (Lewis, Amiri, & Sadler, 2006; Sadler, Chambler, & Zeidler, 2004).Khishfe and Lederman (2006) advocate using SSI to improve students' understanding of NOS. On the other part, having a NOS understanding can help students internalize SSI. Students with advanced NOS understanding could more critically and rationally analyze the socially controversial theories (Pinzino, 2012). According to Liu, Lin, & Tsai's study (2011), students who have a good understanding of NOS, were more likely to recognize different perspectives of SSI. Despite all, NOS and SSI are different areas because NOS refers to values and characteristics of science while SSI is a kind of teaching pedagogy.

SSI provides a pedagogical model dealing with contemporary issues. However, students in ages 9-11 mostly cannot complete their moral development. According to Kohlberg's (1971) theory of moral development, children in age 10-12 obey the rules without questioning and show a respect for the authority. That's why, giving students in elementary level a particular social dilemma and want them to make political and moral judgments can be difficult. Students in elementary level are not able to give a correct decision by alternate between science and policy or ethics. It is enough for them to be aware of the interaction between science and social issues. Thus, explicitly teaching science as a social and institutional system within RFN framework can provide elementary level students clearer understanding of science when compared to SSI. RFN covers professional, organizational, ethical, financial aspect of science in one approach. Although SSI explains social context of science, this study promotes teaching science with RFN framework. Therefore, theoretical framework of this study is based on RFN.

Components of science as a social-institutional system in RFN are professional activities, social organizations and interactions, social certification and dissemination, scientific ethos & social values, political power structures and financial systems. Science is essentially a social-institutional system. Scientists are not isolated from society. Erduran and Dagher (2014) promote inclusion of social-institutional context of science in science education. Scientists and their works are not disassociated from political, governmental and economic issues. Then, students need to have a realistic and holistic understanding of nature of science.

Professional activities as a component of science as a social-institutional system in RFN are activities such as attending conferences, giving presentations about their findings, publishing their works, finding funding, writing research proposals and reviewing research papers (Irzik & Nola, 2014). Scientific ethos are set of attitudes that scientists are expected to follow and internalize in doing scientific works and their interactions with other scientists (Irzik & Nola, 2014). Social certification and dissemination is about evaluating, criticizing, reviewing and publishing scientific works. Social values of science cover respecting the environment and freedom (Erduran & Dagher, 2014). Social interactions and organizations mean that scientists work within institutions, universities and research centers such as NASA and CERN. Political power structures as a component of science as a social-institutional system reveals that there is close link between science and governments (Erduran & Dagher, 2014). Lastly, financial system is closely linked with scientific investigations. It also includes the issues intellectual property, patents, copyrights and licensing commodify science (Erduran & Mugaloglu, 2013).

This study focuses on the teaching social-institutional aspects of science. The theoretical framework of this study based on the reconceptualized FRA-to-NOS developed by Erduran and Dagher in 2014. According to this approach, holistic account of science is not only cognitive-epistemic but also social and institutional system. Science is not just an activity of knowledge production within an epistemic system but is also a social institution within a society (Irzik, 2013). For this reason, science education should increase the awareness of social aspects of science. Without inclusion of social context of science, students cannot gain a true understanding of how scientific work progresses, and how social structures, political and economic relationships influence the improvements and evolutions in science. Presenting social aspects of science in science education offers insight into more holistic understanding of nature of science. Additionally, students are more willing to engage in science when the sociological, political and financial context of science is included in the curriculum (Erduran & Dagher, 2014). Accordingly, science curriculum should include materials that support the acknowledgement of social-institutional aspects of NOS.

1.4 Significance of the study

There have been studies that investigated Turkish science curricula with respect to NOS aspects (Irez, 2009; Kaya & Erduran, 2016a; Özden & Cavlazoğlu, 2015. Kaya and Erduran (2016a) analyzed Turkish science curricula with respect to RFN categories and found that social context of science is underemphasized. This result shows that Turkish students would have a limited understanding of social aspects of science. At this point, teaching science as a social- institutional system explicitly in science classes will provide students with a broader perspective of science. it is suggested that the nature of science and its components should be given explicitly in lessons, and discussions should be made with the whole class after the activities of nature of science are made (Köseoğlu, Tümay & Budak, 2008). The significance of inclusion of social context of science was highlighted: "…science teaching and learning have to situate science in its social context and have to demonstrate that the social dimension is just as integral to science as the cognitive and epistemic dimensions" (Erduran & Dagher, 2014, p. 150).

There is limited research on the RFN in science education and they were mostly curriculum analysis studies or conducted with pre-service teachers. (Erduran, Saribas, Mugaloglu, Kaya, Dagher, & Ceyhan, 2015; Kaya & Erduran, 2015; Kaya & Erduran, 2016a; Kaya, Erduran, Akgün & Aksöz, 2017). Also limited research focused on students' understanding of different aspects in RFN. For example, Karabas (2017) investigated students' understanding of scientific practices which is an epistemic-cognitive aspect defined in RFN. Interventions based on social-institutional dimensions of RFN framework need to be studied to find its effectiveness to improve students' NOS understanding. This study is intended to cover up the deficiency of experimental research in this topic. Therefore, this study attempts to investigate how teaching social-institutional aspects of science will affect students' understanding of social dimension of NOS. In this study, 5^{th} grade students were taught "The Earth, Sun and the Moon" through inclusion of science as social-institutional system as an RFN category to find out the effect of explicit teaching of social-institutional aspects of science.

One of the important variables addressed by this study is the students' attitudes towards science. One of the main purposes of the science education is to understand the nature of science (Kimball, 1967). On the other hand, another major aim of science education is developing positive attitude toward science (Piper and Hough, 1979). Nevertheless, there is limited number of study about relationship between learning NOS and attitude toward science. One study (Harty, Samuel & Andersen, 1991) conducted with pre-service science teachers found that there is no significant correlation between the understanding of NOS and attitudes toward science. However, there is not enough study on how learning NOS effects students' attitudes toward science. For this reason, this study aims to explore attitudes towards science along with NOS understanding.

There are many factors that affect students' attitudes towards science. One of them is related to students' perception that science is a difficult subject area (Black, 1992; Crawley & Havard, 1996). This study aims to find out the effect of presenting the social-institutional aspects of science within RFN perspective on students' attitudes towards science. There has been a move in Europe called "Responsible Research and Innovation (RRI) which emphasizes the importance of presenting the social aspects of science to learners (Macnaghten, Owen, & Stilgoe, 2012). The inclusion of social aspects of science in the classroom may help students learn science more easily (Erduran & Dagher, 2014). However, science classes ignore the sociological foundations of science (Tobbis, 1990).

Moreover, the importance of this study stems from the necessity to conduct research studies that examine the inclusion of social features of science in the science lessons and its effects on students' attitudes toward science. Engaging students in social aspects of science can have a positive effect on their attitudes toward science. This topic needs to be studied. There are limited research about inclusion of social aspects of science in science education and its effect on students' attitudes toward science.

This study was conducted by a teacher researcher and can be considered as an action research. One of the strengths of this study is that teacher researcher can put the plan into action as it should be. Also, researcher is closer to multiple data sources that increase the validity of the study (Merriam, 1998). It is easy to follow process and researcher can reflect on experiences as a teacher. All these strengths support quantitative data.

The purpose of this study is to investigate the effect of teaching science as a social-institutional system within RFN perspective on 5th graders' perception of social dimension of NOS and their attitudes towards science when compared to traditionally designed science instruction. Even if the curriculum is based on a certain theory, no effect can be observed on students as long as the teacher does not apply the curriculum. For this reason, it is important to find out the effects of teaching science as social-institutional system through an experimental research in a school context. "Earth, Sun and Moon" was selected as the subject to teach in this study. The reason for the selection of that topic is that there is limited research about teaching astronomy. Jarman & McAleese (1996) surveyed about 3000 15-year-olds in the UK and found that astronomy scored highest when compared with the other sciences. During interviews with a sample of the pupils, the researchers found that the "farawayness", "unknownness", and excitement of discovery all increase the level of interest. On the other hand, until this academic year, Turkish science curricula have not put enough emphasis on Earth Science topics. Earth science was taught at the end of the academic year. That's why; teachers couldn't have a chance to teach these topics appropriately. Most of the children especially in rural areas are absent from school to work as seasonal workers. Thus, it is worth conducting this study on Earth, Sun and Moon unit which includes many social-institutional aspects of science.

This study is intended to contribute to the elimination of this shortcoming of the curriculum. Therefore, The Earth, Sun and the Moon unit was selected for this study to find out the effect of teaching astronomical phenomena by emphasizing social-institutional aspects of it on students' attitudes toward science and their understandings of NOS. The ultimate goal in this study is to find the effect of inclusion of social-institutional context of science in science education in terms of both NOS understanding and attitudes towards science. For this purpose, following research questions will guide this study:

RQ1: What is the effect of teaching science as a social-institutional system on 5thgrade students' understanding of social-institutional aspects of science when compared to traditionally designed science instruction?

- Is there a significant mean difference between post-test mean scores of the students taught with social-institutional aspects of science and the students taught with traditionally designed science instruction with respect to their understanding about science as a social-institutional system?

RQ2: What is the effect teaching science as a social-institutional system on 5thgrade students' attitudes towards science?

- Are there statistically significant differences between post-test mean scores of the students taught with social-institutional aspects of science and the students taught with traditionally designed science instructions with respect to their attitudes towards science?

RQ3: How will students in the experimental group develop their understanding on social-institutional dimension of science from the first activity to the last activity throughout the intervention?

Null hypothesis

The following two null hypotheses where tested at $p < 0.05$ level of significance on a 2- tailed test.

H_{01}: There is no significant difference between post-test mean scores of the students taught with social-institutional aspects of science and the students taught with traditional science instruction with respect to their understanding of science as a social-institutional system.

H_{02}: There is no statistically significant difference between post-test mean scores of the students taught with social-institutional aspects of science and the students taught with traditional science instruction with respect to their attitudes towards science.

1. 2 Definition of key terms

Nature of Science (NOS)

"The epistemology and sociology of science, science as a way of knowing, or the values and beliefs inherent to scientific knowledge and its development" (Lederman, N. G., Abd-El Khalick, F., Bell, R. L., & Schwartz, R. S. 2002, p.498).

Reconceptualized FRA-to-NOS (RFN)

It refers to Erduran and Dagher's FRA-to- NOS version which provides an educational account and includes pedagogical, instructional, curricular and assessment issues in science education (Kaya & Erduran, 2016a). The key components of the RFN are the aims and values of science, scientific practices, methodology of science, scientific knowledge and social-institutional dimensions of science.

Science as a social and institutional system

It is a sub-category of RFN and means that science is inherently a social system in which scientists working in social groups in social institutions, exercising social values and activities (Erduran & Dagher, 2014).

Attitude

"It is a measure of the subject's expressed preferences and feelings towards an object" (Osborne, Simon& Collins, 2003, p.1054).

Attitude towards science

"…the feelings, beliefs and values held about an object that may be the enterprise of science, school science, the impact of science on society or scientists themselves" (Osborne, Simon & Collins, 2003, p.1053).

CHAPTER 2

LITERATURE REVIEW

This review of related literature is designed to provide background information about the research subject. Firstly, literature on nature of science was reviewed. The various nature of science understandings were presented. Then, theoretical framework of this study, Reconceptualized Family Resemblance Approach to NOS (RFN) was explained. The subject of this study as well as a category of RFN, science as a social-institutional system were highlighted with the help of referring different studies from the literature. The seven components of social-institutional aspects of science were examined as follows: professional activities, scientific ethos, social certification and dissemination, social values of science, social organizations and interactions, political power structures and financial systems. And then, a review of the major literature about attitudes towards science was presented. Finally, the literature on effect of teaching social-institutional aspects of science on students' attitudes towards science was pointed.

2.1 Nature of science (NOS) in science education

NOS has been used as a term in the literature to represent the characteristics of scientific knowledge. On the other hand, some researchers have used this term in a broader context. This broader context includes not only the nature of scientific knowledge but also the nature of scientific enterprise (Cooley & Klopfer, 1963). The question of how to teach the nature of science emerges in science education research. In other words, there is a debate about how the nature of science can be effectively integrated into teaching practices (Turgut, Akçay & İrez, 2010). There are two approaches of teaching NOS, these approaches are implicit and explicit (Abd-El-Khalick & Lederman, 2000).). It is assumed that in the implicit approach students will be able to understand the nature of science by experiencing the scientific process (Yeşiloğlu, Demiröğen & Köseoğlu, 2010). On the other hand, explicit approach argues that the nature of science cannot be taught by simply making experiments and observations. For this reason, it is suggested that the nature of science and its components should be given explicitly in lessons, and discussions should be made with the whole class after the activities of nature of science are made (Köseoğlu, Tümay & Budak, 2008). Apart from the instructional approaches to teach NOS, there are also many assessment tools to test the understanding of NOS in science education literature. The most popular assessment tools are Test on Understanding Science (TOUS) developed by Cooley & Klopher in 1961, Nature of Science Scale (NOSS) developed by Kimball in 1968, Nature of Scientific Knowledge Scale (NKSK) developed by Rubba in 1976. There is limited research on assessing social dimension of science. One of them is Test on the Social Aspects of Science (TSAS) developed by Korth in 1969.

There are many NOS understandings in the philosophy of science literature. One of them so called, "consensus view" has been adopted in the science education literature (Abd-El Khalick, 2012; Lederman et al., 2002; McComas, 1998). The key aspects of this approach are the tentative nature of scientific knowledge, observation, inference, and theoretical entities in science, the theory-laden nature of scientific knowledge, the creative and imaginative nature of scientific knowledge, the social and cultural embeddedness of scientific knowledge, scientific theories and laws, myth of the scientific method (Lederman et al., 2002). Lederman and his colleagues support the explicitly teaching the nature of science rather than implicitly teaching.

According to Lederman, these seven elements of NOS fulfill the criteria of:

(i) accessibility to school students;

(ii) wide enough agreement among historians and philosophers; and

(iii) being useful for citizens to know(Matthews, 2012, p. 7). One positive side of this list is that it helps researchers to prepare an instrument to measure NOS learning and, it can provide students and science teachers with a compact knowledge about NOS (Matthews, 2012). On the other hand, these statements of consensus view have been criticized. Firstly, consensus view oversimplifies the nature of observation, theory and modeling. Also, it does not give a place to inquiry in spite of the fact that inquiry is an inseparable part of science. NOS understanding also needs to be applied in any context (Ford, 2008). In other words, it should be functional and compatible, not declarative (Rudolph, 2000). One of the aims of NOS teaching is to make students to evaluate scientific evidence and make judgment about it (Allchin, 2011). Therefore, imposing the common characteristics of science on students conflicts with the NOS understanding.

Another perspective to characterize NOS is Whole Science proposed by Allchin (2011). His perspective does not exclude essential elements of science. Instead, it includes many items such as motivation, role of funding, peer review, cognitive biases that are absent in “consensus view” because scientific work includes social interactions besides cognitive methods (Erduran & Dagher, 2014; Longino, 1990; Shapin, 1996).

Science is more than the seven elements of Lederman’s “consensus view”. For this reason Matthew (2012) broadened the nature of science beyond consensus view by changing focus from NOS to Feature of Science (FOS). He suggested additional features to science. These are idealization, modeling, experimentation, mathematization, technology, worldviews, religion, feminism, constructivism and realism (Matthew, 2012). However, Matthew does not give reasons for why he selected these specific features and not others (Erduran & Dagher, 2014). In addition, these additional features are disparate ideas from various discipline, some of them explain epistemological aspects of science (explanation) while others are related to philosophical point of views (feminism, constructivism) (Erduran & Dagher, 2014).

Irzik and Nola (2011a, 2014) developed Family Resemblance Approach to characterize science based on notion of family resemblance on Wittgenstein's work. This scheme is an alternative to the consensus view because of its more comprehensive and systematic structure (Irzik & Nola, 2014).

The family resemblance model of nature of science conceptualizes science in terms of a cognitive-epistemic and a social-institutional system. Science as a cognitive- epistemic system includes process of inquiry, aims and values, methods and methodological rules, scientific knowledge. On the other hand, science as a social- institutional system includes professional activities, scientific ethos, social certification and dissemination of scientific knowledge and social values. The fundamental principle of this framework is that there are characteristics common to all sciences some are specific for a particular sciences (Erduran&Dagher, 2014). For instance, experimentation cannot be used in astronomy while it is frequently used in biology.

As mentioned earlier, FRA to NOS provides a systematic structure for characterizing science. However, it is in textual format and needs to be more comprehensive in order to use in science education. For this reason, Erduran and

Dagher (2014) extended Irzik and Nola's (2011) FRA by offering an interactive and comprehensive representations to contribute to research on Nature of Science (NOS).

2.2 Reconceptualized family resemblance approach to NOS (RFN) in science education

Erduran and Dagher reconceptualized Irzik and Nola's FRA to use it in science education (2014). The terminology of "Reconceptualized FRA-to-NOS is used to differentiate the Erduran and Dagher' FRA version from the various accounts of the family resemblance idea (Erduran & Kaya, 2016a). The original FRA model has been modified by Erduran and Dagher (2014) to include three additional categories to science as a social and institutional system. These are: financial systems, political power structures and social organizations and interactions. These aspects of science are not explicit in Irzik and Nola's (2014) framework.

The Irzik and Nola's (2014) RFA conceptualization is in a textual format. Erduran and Dagher (2014) proposed a wheel image to visualize the holistic account of NOS. As can be seen in Figure 1, this new concentric circle model represents science as an interactive system. Previous NOS understandings such as consensus view tend to offer disconnected ideas about science.

The new conceptualization of RFN represented in Figure 1 provides a holistic and more comprehensive image of science. It is also pedagogically useful. As seen in the Figure 1, categories in science as a cognitive-epistemic system are at the center. The larger circle consists of the components of science as social-institutional system. The components in each circle are interconnected. At the center of the wheel there are scientific practices, scientific knowledge, aims and values and method and methodological rules.

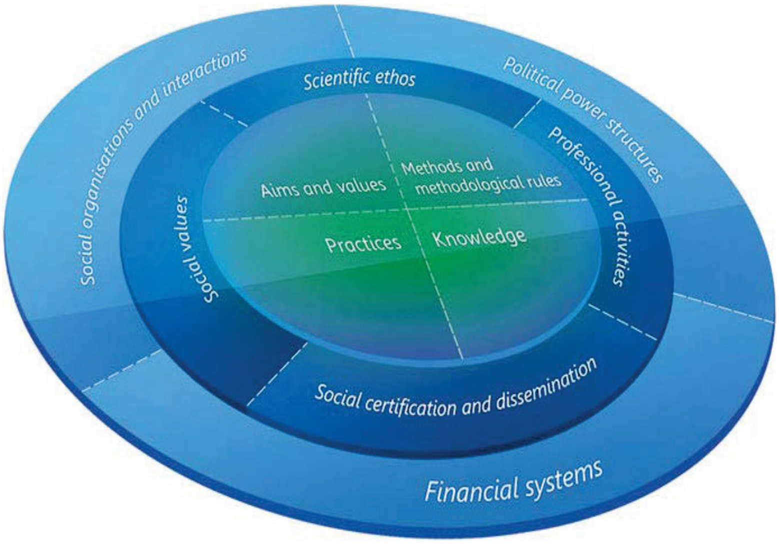


Fig. 1 FRA wheel: science as a cognitive-epistemic and social-institutional system (Erduran & Dagher, 2014, p.28)

Scientific practices include activities, modeling, real world, prediction, data and explanation. Erduran & Dagher (2014) proposed a heuristic “Benzene Ring” in an attempt to unite together disparate components of science and to redefine scientific practices by giving place to social aspects of practices. Another cognitive-epistemic category is method and methodological rules. One of the important learning goals of science education is to understand that there is variety of scientific methods. Establishing complex scientific knowledge requires evidence from variety of methods. For this reason, Erduran and Dagher (2014) proposed a scheme called “gears” image to illustrate the diversity of methods in science. This scheme contains hypothesis testing, non-hypothesis testing, manipulative and non-manipulative description that work together to contribute to scientific theory. This image of gears can be used as a pedagogical tool to teach scientific methods. Third cognitive-epistemic category, scientific knowledge explains that the products of scientific enterprise are theories, laws and models (TLM) work together and generate explanations for a natural phenomenon (Erduran & Dagher, 2014).

Erduran and Dagher (2014) reconceptualized the Family Resemblance Approach (RFN) for the purpose of applying it in science education. They proposed eight different visual tools that corresponds various aspects of nature of science. The importance of visualization in science learning has been reported in many studies (Gilbert, 2005; Krajcik, & Soloway, 2001). Visualization helps conceptualization and memorization. For this reason, visual tools have pedagogical utility. These images in RFN are collectively called "Generative Images of Science" (GIS) since each image has the potential to be expanded and developed. In a nutshell, science is either cognitive-epistemic or social-institutional system. Students need to learn the social context of science incorporated into science classes. Otherwise, they have limited understanding of how social factors affect science.

2.3 Science as a social-institutional system

Science is essentially a social-institutional system. Scientists are not isolated from society. They work in institutions within a social group. Many nature of science understandings make reference to social embeddedness of science and scientific knowledge. For instance consensus view describes scientific knowledge as social and cultural embedded (Abd-El Khalick, 2012; Lederman et al., 2002). However, science is not described as a social system in this view. On the other hand, Whole Science proposed by Allchin (2011) includes essential components related to social-institutional aspects of science such as peer review and role of funding but it does not present a holistic account of science. Another NOS understanding Feature of Science (FOS) developed by Matthews (2012) emphasizes on different epistemological and philosophical ideas but it does not entirely cover the social dimension of science. Irzik and Nola (2014) describe science as a cognitive epistemic system as well as a social system in their family resemblance approach to nature of science. The social system includes professional activities, scientific ethos, social certification and dissemination of scientific knowledge and social values. Irzik and Nola (2014) do not claim that their approach is the only and best way of describing science as a social system. The categories of science as social system in family resemblance approach to nature of science are open-ended and can be broadened. In response, Erduran and Dagher (2014) described three additional categories related to the political, economical and institutional context of science in order to have a more holistic and comprehensive understanding of NOS.

Erduran and Dagher (2014) promote inclusion of social-institutional context of science in science education. Scientists and their works are not disassociated from political, governmental and economical issues. Then, students need to have a realistic and holistic understanding of nature of science. Erduran and Dagher's reconceptualized family resemblance approach to nature of science (RFN) describes science as a cognitive-epistemic system as well as a social institutional system. Science as a social-institutional system consists of seven categories that are needed to be included in science education. These categories are professional activities, scientific ethos, social certification and dissemination, social values of science, social organizations and interactions, political power structures and financial systems. Each category is summarized in a visual representation proposed by Erduran and Dagher in 2014. The image of wheel that summarizes all the seven components of science as a social and institutional system is given in Figure 2.

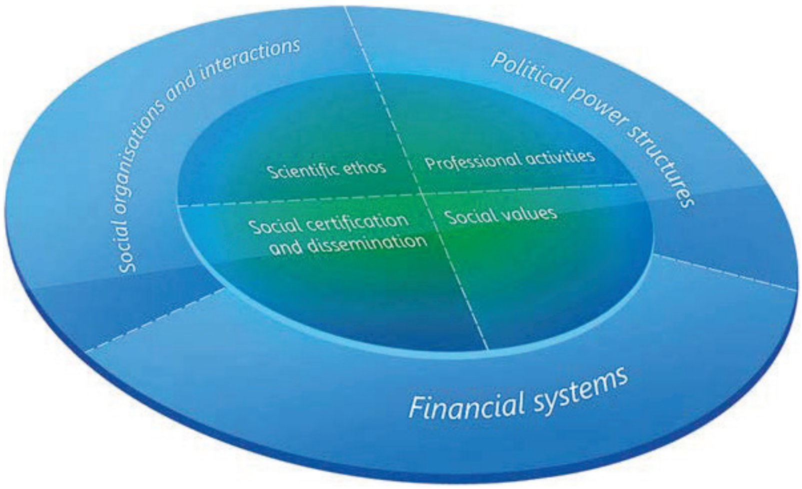


Fig. 2 Science as a social-institutional system (Erduran & Dagher, 2014, p. 143).

2.3.1 Professional activities

One of the components of the social-institutional dimension of science is professional activities. Apart from producing knowledge, scientists engage in professional activities such as attending conferences, giving presentations about their findings, publishing their works, finding funding, writing research proposals and reviewing research papers (Irzik & Nola, 2014). In school science it is often ignored that scientists are embedded in a community of practice. Community of practice was defined by Wegner and Snyder as “they are groups of people informally bound together by shared expertise and passion for a joint enterprise” (2000, p. 139). Erduran and Dagher (2014) proposed modeling scientific community in the context of science classroom. Turkish science curriculum (MEB, 2013) is based on constructivist approach. Especially social constructivism promotes discussion of ideas and presentation of finding in the classroom (Kaline & Powel, 2009). That’s why, teachers can create professional activities in the science lessons by using constructivist teaching techniques such as peer review or group presentation.

2.3.2 Scientific ethos

Another important issue about social context of science is scientific ethos. Scientific ethos are set of attitudes that scientists are expected to follow and internalize in performing scientific works and their interactions with other scientists (Irzik & Nola, 2014). There are many norms defined by scientists. For example, Merton (1968) defined four principles for scientists. These norms are universalism, skepticism, disinterestedness and communalism. Resnik (2007) identified intellectual honesty, respect for the environment, freedom and openness as ethical norms that are necessary in carrying out a scientific activity. Scientific ethos can be used in science teaching both explicitly and implicitly. Students can experience epistemic and social values by engaging in classroom activities such as solving a real life problem (Frazer & Kornhauser, 1986).

2.3.3 Values of science

In addition to scientific ethos, students also should be aware of the values of science. Respecting the environment and freedom can be considered as social values of science (Erduran & Dagher, 2014). In the history of science, many scientists have exposed to religious and ideological constraints. Students need to be aware that scientists and scientific works can be affected or restricted by ideological and religious restraints (Erduran & Dagher, 2014). Therefore, cultural climate have an impact on scientific enterprise.

2.3.4 Social certification and dissemination

As mentioned before, scientists engage in many professional activities. Their scientific works are criticized, evaluated and reviewed by other scientists in such large communities. Scientists try to publish their scientific findings to increase their recognition (Erduran & Dagher, 2014). A scientific work is not only the product of individual scientist. It is the result of collaborative efforts of the community (Kitcher, 2011). In school science, students can work collaboratively to improve their learning skills (Gokhale, 1995). Students may have a chance to discuss and take responsibility as well as become critical thinkers through collaborative learning (Totten, Sills, Digby & Russ, 1991). Organizing peer reviewing activities in science classroom can facilitate students' awareness about social certification and dissemination.

2.3.5 Social organizations and interactions

Social organizations and interactions mean that scientists do not always work alone. They work within institutions, universities and research centers. Scientists are embedded in a community of practice. In each institution, there is a job sharing. Each group of scientists works on a particular project. One study (Türkmen, 2008) that investigated Turkish primary students' perception about scientist found that students think scientists work alone indoor without any interaction with society. In order to change this point of view, science teachers should mention institutions, universities and research centers. For example, CERN, NASA, TÜBİTAK are the examples of national and international research centers in which many scientists work together. In addition, scientific enterprise is closely related to business because many firms receive support from scientists. On the other hand, many scientists establish their own firms. For example Thomas Edison was a scientist as well as a company owner of various electric companies (Israel, 1998). In a nut shell, students need to know how scientists work within social organizations.

2.3.6 Political power structures

In school science, students learn a sterile account of science independent from society and its interests. In this way, students might have an unrealistic understanding of science because there is close links among science, governments and states (Erduran & Dagher, 2014). In the history of science there has been always a relationship between science and governments. For instance, Galileo repaired his telescope in order to see the enemy fleets better (Fermi & Bernardini, 2003). On the other hand, Heisenberg contributed to Hitler's scientific project that caused oppression and intimidation (Rose, 2002). Additionally, Apollo 11 mission was one of the most significant events in the Space Race between the United States and the Soviet Union (Cadbury, 2007). Students need to know that there is an ideological power of science. Science education has the responsibility to disclose how a scientific work becomes a tool for governments' colonial and economic interests (Erduran & Dagher, 2014).

2.3.7 Financial systems

Erduran and Dagher (2014) proposed "financial system" as an additional component for social-institutional aspects of science. In order to carry out scientific investigations, scientists need to have resources that are supplied by states, governments and other institutions. For instance, TÜBİTAK funds scientists so that they can carry out investigations. Recent years, commercialization of academic science has been discussed. Irzik and Nola (2013) in some disciplines such as computer science, communication and information sciences, genetic engineering, pharmacology and biomedicine, scientists do scientific research to make profit. Additionally, there are many concepts such as intellectual property, patents, copyrights and licensing that commodify science (Erduran & Mugaloglu, 2013). Science is considered as a market and profit opportunity anymore. Erduran and Dagher clarified this situation by stating "The role of the scientists in this scenario is one of a producer or supplier of scientific information" (2014, p. 149). This means that science and industry work together to make profit. Students need to understand the financial dimension of science and science as a social-institutional system is tied to economic factors.

Turkish science curriculum

This study was applied by using the new Turkish science curriculum which went into operation in 2017. It is important to have an idea of what the curriculum says about NOS. That's why; this paragraph forms a frame for the Turkish science curriculum and gives details about it. Turkish science curriculum has scientific method skills as one of the main domain-specific skills. These skills are stated as "skills that scientists use in their work, such as observing, measuring, classifying, recording data, constructing hypotheses, using and modelling data, modifying and controlling variables, and experimenting" (MEB, 2017, p. 9). Experiencing these skills is significant to understand the nature of science (NOS).

The new Turkish science curriculum first applied in 2017 in 5th grade students includes several changes in terms of the subject sequence and selection. For instance, the first unit "The Human Body Systems" in previous 5th grade science curriculum (MEB, 2013) was completely removed in the new curriculum and replaced with the "Human and Environment" unit (MEB, 2017). Additionally, in all grade levels, "Earth and the Universe" subject area was placed in the first units. When the Turkish science curriculum 2017 is examined, it can be seen that there is few changes in the vision of the current teaching program, teaching philosophy, teaching methods and techniques. In both curriculum (MEB, 2013; MEB, 2017) the main purpose is indicated as educating all students as scientifically literate individuals. One important change is that engineering and design is added as the last unit of each grade level with the innovative thinking skills. In the curriculum, this field is defined as "the integration of science with mathematics, technology and engineering" (MEB, 2017, p. 10). It is also observed that "STSE (Science-Technology-Society-Environment) program" in MEB 2013 curriculum (p. 6) has been changed to "SETSE (Science-Engineering-Technology-Society-Environment)" in MEB 2018 curriculum (p. 10) by adding engineering. From the nature of science (NOS) perspective, "universal moral values, national and cultural values, ethics" (MEB, 2017, p. 9) are intended to be adopted as essential principles in the new curriculum. These principles are not present in the 2013 curriculum. On the other hand, "science is the result of collective effort of scientists from all cultures" (MEB, 2013, p. 2) and "developing a sense of appreciation of science" (MEB, 2013, p. 2) principles were removed from the new curriculum. All in all, the current Turkish science curriculum underemphasizes the social and institutional context of science while it places importance on engineering and design.

2.4 Research on RFN

The development of RFN was presented in this part respectively. Erduran and Dagher (2014) extended the Irzik and Nola's (2014) Family Resemblance Approach (FRA) to the NOS by adding different categories such as financial systems and political power structures and proposing pedagogical applications for science educations. Later on, Kaya and Erduran (2016a) named Erduran and Dagher's (2014) version of FRA as "Reconceptualized Family Resemblance Approach to Nature of Science" (RFN). RFN consists of 11 categories that include the cognitive, epistemic and social-institutional aspects of science in a holistic way. Within this approach, there have been some empirical studies based on the application of RFN categories in teacher education and secondary school science education (Akgun, Kaya, Erduran & Aksoz, 2017, Aksoz, Kaya, Erduran, Akgun & Tas, 2016, Karabaş, 2017, Saribas & Ceyhan, 2015, Tas, Cetin, Kaya, Erduran, Akgun & Aksoz, 2016). Additionally, the curriculum analysis studies based on the RFN approach have also been conducted (Kaya & Erduran, 2016a; Kaya & Erduran, 2016b). Interventions based on the RFN are still continuing.

2.5 Attitude towards science

Students' attitude towards science has been a significant subject in science education research community for 40 years. Recent years, it was found that youth are becoming less interested in pursuing science careers in the USA (Xie & Achen, 2009). The study conducted by Korkut Owen, Kelecioğlu and Owen (2014) shows that the highest increase in the years between 2002 and 2012 is in the field of Social Sciences.

Attitude can be defined as a measure of someone's expressed preferences and feelings towards an object (Obsorne, Simon& Collins, 2003). It is important to draw fundamental distinction between "attitudes toward science" and "scientific attitudes". Scientific attitudes are more related to scientific thinking that includes questioning approach, searching for data, respect for logic, a demand for verification and consideration of premises and consequences (Education Policies Commission, 1962). On the other hand, attitudes towards science was defined as "the feelings, beliefs and values held about an object which may be the enterprise of science, school science, the impact of science on society or scientists themselves" (Obsorne, Simon& Collins, 2003, p. 6). Many studies have drawn a range of components in measuring attitudes towards science (Crawley & Black, 1992; Gardner, 1975; Koballa Jr., 1995). These components include the perception of the science teacher, anxiety toward science, the value of science, self-esteem at science, motivation towards science, enjoyment of science, attitudes of parents towards science, the nature of classroom environment, achievement in science, fear of failure on course and attitudes of peers and friends towards science (Obsorne, Simon& Collins, 2003).

Attitudes are commonly measured through the use of questionnaires that generally consist of likert scale items. The items are statements which reflect favorable or unfavorable opinions about the subject being studied. The statements have 5 point choice respectively: strongly agree, agree, not sure, disagree and strongly disagree. Many instruments have been developed to measure attitudes towards science. Most known and used scientific attitude inventory was developed by Moore and Sutman in 1972. Attitudes Towards Science Inventory was developed by Gogolin and Swartz in 1992. Additionally the VOST (Views on Science-Technology- Society) was developed by Aikenhead and Fleming in 1992. There are also qualitative methods to study attitudes towards science. Researchers can make interviews to collect richer data.

Researchers have identified many factors that influence students' attitudes towards science. Broadly, the gender, personality, structural variables and curriculum variables can be defined as the factors that influence students' attitudes towards science (Osborne, Simon& Collins, 2003). According to Krapp and Prenzel (2011), students' attitudes towards science and technology depend on the type of instruction which is given to students in school context. There have been many studies which compare the instructional techniques or curriculum in terms of their effects of students' attitudes towards science (Gibson & Chase, 2002; Hofstein & Lunetta, 1982). However, there is limited empirical research about teaching social-institutional aspects of science and its effect on students' attitudes towards science. The inclusion of sociological, financial, political and organizational context of science in science lessons can improve students' interest and engagement in science (Erduran & Dagher, 2014). Therefore, this study will investigate the effects of inclusion of social-institutional aspects of science in science lessons on students' attitudes towards science as well as their nature of science understanding.

This study also brings a new perspective to the astronomy teaching. Astronomy is one of the oldest scientific disciplines. Human being's curiosity about the shape and movement of the Earth and its relation with the Sun and the Moon have contributed to scientific inquiry, civilizations and cultures (Aslantürk, Bolat, Kalkan, Kiroğlu & Türk, 2014). Studies related to astronomy education have been increased by the launch of Sputnik in 1957 (İskeleli, Kalkan, Kıroğlu & Türk, 2015). However, 6-13 years old students still have strong problems in understanding astronomical phenomena (Benacchio, 2001). A study (Bilen, Ercan & Ural, 2016) found that web-based teaching method increased academic achievement and positive attitudes in the fifth grade Science unit, "System of Earth, Sun and Moon". However, there is not enough study on how teaching social-institutional dimension of astronomy affects students' attitudes towards science. Therefore, the effectiveness of this method should be tested in the unit of "System of Earth, Sun and Moon" in science education.

2.6 Summary of the literature review

Nature of science (NOS) has become an important area of research in science education in the last few decades (Erduran & Dagher, 2014). Typically, NOS refers to the epistemology and sociology of science (Lederman, N. G., Abd-El Khalick, F., Bell, R. L., & Schwartz, R. S. 2002, p.498). There are various understandings of NOS in the literature (Lederman et. all, 2002; Matthews, 2012; Irzik & Nola, 2014). One of them is "consensus view" that defended seven elements of NOS. However, these seven elements describe mostly the scientific knowledge and oversimplify observation, theory, modeling and inquiry. Allchin' (2011) perspective to characterize NOS is Whole Science that does not exclude social elements of science. Another view, Feature of Science (FOS) proposed by Matthews (2012) suggested additional features such as worldviews, religion and feminism to science. On the other hand, Irzik and Nola (2011a, 2014) developed Family Resemblance Approach to characterize science based on notion of family resemblance on Wittgenstein's work. This scheme is an alternative to the consensus view because of its more comprehensive and systematic structure (Irzik & Nola, 2014). The family resemblance model of nature of science conceptualizes science in terms of a cognitive-epistemic and a social-institutional system. The fundamental principle of this framework is that there are characteristics common to all sciences some are specific for a particular sciences (Erduran & Dagher, 2014).

Erduran and Dagher reconceptualized Irzik and Nola's FRA to use it in science education (2014). The terminology of "Reconceptualized FRA-to-NOS is used to differentiate the Erduran and Dagher' FRA version from the various accounts of the family resemblance idea (Erduran & Kaya, 2016a). The original FRA model has been modified by Erduran and Dagher (2014) to include three additional categories to science as a social and institutional system. These are: financial systems, political power structures and social organizations and interactions. These aspects of science are not explicit in Irzik and Nola's (2014) framework. RFN perspective offers a wheel image to visualize the holistic account of NOS. This new concentric circle model represents science as an interactive system. Previous NOS understandings such as consensus view tend to offer disconnected ideas about science. The new conceptualization of RFN provides a holistic and more comprehensive image of science. It is also pedagogically useful (Erduran & Dagher, 2014). For this reason, the theoretical framework of this study is based on the Erduran and Dagher's (2014) RFN perspective.

CHAPTER 3

METHODOLOGY

This chapter includes the research methodology of the thesis. Specifically, research design, participants, instruments to collect data, implementation and data analysis were described.

3.1 Research design

In examining the effect of teaching social-institutional aspects of science framing with RFN, quasi-experimental design is preferred. This design is useful in circumstances where it is not possible to randomize groups (McMillan & Schumacher, 2006). Quasi-experimental design refers to the application of experiment and interpretation of data without random assignment (Cook, Campbell & Shadish, 2002). In other words, its purpose is to test causal relationships especially in social settings without taking into account the pre-existing factors (Campbell & Stanley, 1963). Therefore, this study was carried out using quasi-experimental method and the pre-test post-test design with randomly selected groups.

The study adopts pre-test, post-test quasi-experimental design and includes following variables: one independent variable with two levels (teaching science traditionally and teaching science as a social-institutional system) two dependent variables (understanding of social-institutional dimensions of science and attitudes towards science). The study was implemented at the first semester of the 2017/2018 academic year.

3.2 Participants

A group of forty two fifth grade students were randomly selected from one of Turkish public elementary school from İstanbul, Fatih in the school year 2017-2018 (19 students in the experimental group and 23 students in the control group). The school has a large population of fifth grade students distributed in 8 classes. Each class has approximately 30 children of low socio-economical status. Also, each class includes 2-4 Syrian students. Syrian students were not included in the sample since they cannot speak and understand Turkish. Some of the students in both groups were habitually absent from school. These students were also not included in the sample. Convenience sampling was used for the selection of school because the researcher implemented the study as teacher. Convenience sampling is a non-probability sampling method where participants are selected because of their convenient accessibility to the researcher (Castillo, 2009).The participants in this study have been already distributed into two classes of fifth grade by the school administration.

Students in both groups were studying their first year in middle school and their age ranged from ten to eleven. Fifth grade students usually have four class hours science instruction per week. Each lesson lasts for 40 minutes. Apart from science lessons, fifth grade students in both groups have two hours additional science lessons called “elective applied science” per week. In other words, students in both experimental and control groups have six class hours science instruction per week in total. One of the classes was chosen as an experimental group, which was taught with RFN perspective *(n=19).* The other group was chosen as a control group was taught with traditionally designed science instruction *(n=23).*The researcher was the teacher at the same time. She implemented the instructions for both experimental and control groups. The teacher had one year teaching experience. She was a graduate of the science teaching department of the Education Faculty.

3.3 Data collection tools

Two instruments were used to collect quantitative data. Social-Institutional Questionnaire (SIQ) was used to measure students' understanding of social-institutional aspects of science. Scientific Attitude Inventory (SAI) was used to measure students' attitudes towards science. On the other hand, interviews and students' worksheets were used as qualitative data collection instruments. Data collection tools will be explained in given order.

3.3.1 Social-institutional questionnaire (SIQ)

Social-Institutional part of the Nature of Science (NOS) Questionnaire developed by Kaya, Erduran, Akgün and Aksöz (2017) was used to examine students' understanding of social dimension of science. The scale originally includes subcategories. Only the category of social-institutional aspects of science was administered to students. That's why; the questionnaire was called as "Social-Institutional Questionnaire (SIQ) in this study. The original scale was developed for pre-service science teachers. This study was adapted to items of the scale for 5th grade students. The original scale includes 20 items. The scale that will be used in this study includes 15 items about social-institutional aspects of science. The 5 items related to teaching social-institutional system of science was removed to conduct the questionnaire to 5th grade students. Before the study, the scale was administered to 136 5th grade students. As a result of reliability analysis, Cronbach Alpha coefficient was found as 0.62. The items in the scale cover the seven components of social-institutional dimension of science. A typical 5-level likert scale was used and the following quantitative values were given: Strongly disagree (1)", "Disagree (2)", "Neither agree nor disagree (3)", "Agree (4)" and "Strongly agree (5)". No negative statements were given in the test to prevent the students from confusion. The test was administered to two groups as pre-test and post- test. SIQ can be found in Appendix A.

There are some issues faced when the social-institutional part of the NOS questionnaire was adapted from pre-service teachers to 5th grade student. Firstly, some of the items were simplified. For example the item "Science is a social system." was converted to "Science emerges in society.", because students could not understand the social system. Furthermore, some of the items were excluded from the questionnaire. "There are a number of hierarchies among science teams, and these hierarchies can change." is too complex for 5th grade students. That's why, it was excluded. By doing this, it was taken into consideration that all items are corresponding to one of the seven social-institutional aspects of science.
Also, when the SIQ was first applied in students to find its reliability, some of the students asked the meanings of some of the words from the scale such as "politics" and "article". These words were defined briefly by teacher in class.

3.3.2 Scientific attitude inventory (SAI)

Many of the scales developed to explore students' attitude towards science have been examined for this study. As a result, it was found that the Scientific Attitude Inventory (SAI II) developed by Moore and Foy (1997) has been structured to include both affective domain and scientific attitudes. For this reason, SAI was used in this study despite the fact that it was developed many years ago. This scale has been already adapted to Turkish by Demirbaş and Yağbasan in 2006. It is thought that adaptation of this scale to the Turkish will contribute to the field that lacks the evaluation of affective domain (Demirbaş & Yağbasan, 2006). The scale was developed by Moore (1973) for the first time and 60 items of the scale was reduced to 40 items as a result of changes over time. Also some other necessary arrangements were made in the scale. In the next paragraph, the characteristics of the scale adapted to the Turkish are given.

The original scale is in English and it includes six subcategories and forty items. Adaptation from English to Turkish started with translation then it was submitted to the specialists for analysis in terms of language, content and range. The scale was administered to 300 students in 6th, 7th, 8th classes of primary schools. As a result of reliability and validity analysis, Cronbach Alpha coefficient was found as 0.76, Spearman Brown Correlation was found as 0.84. An example item from the scale is "Only highly trained scientists can understand science. The search for scientific knowledge is boring." As seen in the example, the language is simple enough to be used with 5th grade students. A typical 5-level likert scale was used and the following quantitative values were given: Strongly disagree (1)", "Disagree (2)", "Neither agree nor disagree (3)", "Agree (4)" and "Strongly agree (5)". The ten of the forty items are negative. The scoring for the negative items was reversed. Scientific Attitude Inventory (SAI) was administered to two groups as pre-test and post- test. All items in SAI can be found in Appendix B.

SAI is also divided into 6 sub-scales. Five of the subscales are related to the nature of science, the way scientists work; one subscale included items about what students felt about science. Details are given in Table 1.

Table 1. Content, Subscales and Score Ranges of Scientific Attitude Scale Items (Demirbaş & Yağbasan, 2016, p. 281)

Sub-scales	Number of Item	Subscale Content	Item Numbers in the Scale	Score Range
1	3+3=6	Scientific Laws and the Structure of the Theories	(4,16,34); (11,15,35)	6-30
2	3+3=6	The Structure of the Science and Its Approach	(10,19,33); (2,7,26)	6-30
3	3+3=6	Displaying Scientific Behavior	(17,18,25); (3,5,32)	6-30
4	3+3=6	The Structure and Purpose of Science	(20,21,28); (9,24,31)	6-30
5	3+3=6	The place and Importance of Science in Society	(12,23,29); (6,8,38)	6-30
6	5+5=10	Willingness to Make Scientific Studies	(1,27,30,36,40); (13,14,22,37,39)	10-50
Positive Items	20	-	-	20-100
Negative Items	20	-	-	20-100
Total	40	-	-	40-200

3.3.3 Qualitative data collection tools

The qualitative data was collected through interviews and students' worksheets. Three of the students in the experimental group were interviewed after intervention. Additionally, worksheets collected from all students in the experimental group were used to gain further insight into students' understanding of the social dimension of science.

3.3.3.1 Interviews

In this study, interviews were used for qualitative data collection. Since the interviewing is one of the best techniques that helps researcher find more reliable evidence on students' thoughts (Cummins, 1992), three of the students in experimental group were interviewed after intervention. Students in the control group were not interviewed. As in social-institutional questionnaire, the questions in the interview focus on diagnosing the participants' alternative conceptions about the social dimension of science, in order to explain, interpret and support the findings obtained from SIQ. The interview protocol (see in Appendix C) consisting of nine questions and that was conducted with three students from the experimental group. In order to support quantitative data of the study, three students who are less developed, highly developed and did not show meaningful development according to their pretest and posttest scores were interviewed after the intervention. In other words, one student whose SIQ score increased extremely, one student whose SIQ score showed a little improvement, one student whose SIQ score remained almost the same after intervention were selected to interview. Some example questions from the interview protocol follows "Where do scientists research?", "Imagine that you are a scientist and develop something very important and valuable. What would you do to make everyone aware of this?".

3.3.3.2 Students' worksheets

In addition to interviews, qualitative data was also obtained from experimental group students' activity sheets. Throughout the treatment, four worksheets were distributed to each student in experimental group. Sunspots, Life on the Moon, Moon Phases and Moon Mining are the topics of the four worksheets. The worksheets consist of reading texts, questions, group reports, self-reports and a scoring rubric for peer review activity. Students' development was diagnosed through interpretation of the activity sheets. Also, the frequencies of the social-institutional components of RFN were determined from the responses and drawn conclusions.

3.4 Implementation

This study was carried out within the context of the unit The Earth, Sun and the Moon, which is part of the current secondary school fifth grade curriculum. The unit begins with the structures and characteristics of the Sun and Moon. Then the phases of the Moon are presented. Finally, how the Sun, Earth and the Moon move relative to each other is learnt. The researcher of this study taught the students in both groups the same intended scientific topics. In both experimental and control group, the same instructional techniques were used. In the experimental group, the researcher introduced the students with the same topics but she administered to activities that are mainly based on social dimension of science framing with RFN. The instructions that were implemented to the experimental group emphasize the seven components of social-institutional part of the RFN. These are professional activities, social organizations and interactions, social certification and dissemination, scientific ethos, social values, political power structures and financial systems (Erduran & Dagher, 2014). Each component was discussed with the students in class. The detailed lesson schedule for the experimental group can be found in Appendix D.

Before starting the unit, Scientific Attitude Inventory (SAI) and Social-Institutional Questionnaire (SIQ) were administered to all students as pre-test. After that, the Earth, Sun and Moon unit lectures were taught during 4 weeks (15-16 hours in total), in line with the fifth grade science curriculum (MEB, 2017). While the control group was taught without the inclusion of social dimension of science, the experimental group taught with special designed instructions enriched with the understanding of science as a social-institutional system. At the end of the 4 weeks, both control and experimental groups were given SAI and SIQ as post-tests.

Both experimental and control groups' lesson plans include various instructional techniques such as brainstorming, K-W-L, group discussion, question-answer method, peer review. While group discussion, peer review, brainstorming, question-answer methods facilitate learning NOS, K-W-L chart was used to help students organize information and monitor their progress in both experimental and control groups. K-W-L was also used for assessment.

3.4.1 Experimental group's instructions

Experimental groups' lesson plans include objectives related to social-institutional aspects of science. The subject of the first lesson in experimental group is "Sunspots" (Sunspots lesson plan can be found in E). Students learnt the concept of economy as well as the properties of science as a curriculum goal. In this lesson, students developed their reasoning skills. The Sunspot activity is based on using scientific knowledge to come up with a conclusion. British economist William Stanley Jevons (1870) said that there was a relationship between sunspots and economic crises. Students developed cause and effect relationship to prove this claim with the help of given data. Also students first developed an explanation individually then they generated explanations as a group. This activity promotes the idea that the scientific knowledge or claim includes collective and collaborative work of the community (Erduran &Dagher). Students tried to state good reasons to convince their group mates. Control group also learn sunspots but without emphasis on economy. They were given properties of the Sun. There was no emphasis on relationship between the economy and science.

The second activity was “Galileo Galilei” (see in Appendix F) for the experimental group. Curricular objective of this lesson is that students will be able to indicate the Sun’s rotational movement. The teacher also taught the Copernicus’s model of heliocentric system which says that the Sun, not the Earth, is the center of our solar system. On the other hand, RFN objective of the lesson is that students will be able to aware that scientific works can be restricted by ideological or religious constraints. Students read the life of Galileo and discussed restrictions he encountered in his life. At the end of the lesson brainstorming on intellectual honesty was made. Student had an idea of intellectual honesty. Shortly, students internalized social values of science and scientific ethos as the categories of social-institutional aspects of science. On the other hand, in control group students learnt Sun’s rotational movement and Galileo’s contributions to the history of science but no emphasis was given on scientific ethos, social values and intellectual honesty.

The third lesson of experimental group was “Life on the Moon”. The lesson plan for “Life on the Moon” can be found in Appendix G. This lesson began with KWL strategy. KWL stands for Know, Want to Know and Learned and it helps students organize their knowledge before, during and after a lesson and monitors their learning (Ogle, 1989). KWL charts were applied in both experimental and control groups. Students wrote what they know and want to know about the Moon. The characteristics of the Moon were given and experimental group watched a video about Moon landing distinctively. This video mentions Apollo 11 which was the first spaceflight with humans on the Moon. This event is also related to the space race between the United States and the Soviet Union. That’s why; students saw and discussed the political side of science. The body of the fourth lesson was a group activity. Students were given a scenario. According to the scenario, students imagined that they are working on space sciences. NASA is organizing a major international congress, World Moon Congress, about survival on the Moon. The task of groups is to prepare and present a report about life on the Moon. At this point, teacher informed students that scientists engage in professional settings such as attending conferences. They also review, evaluate and validate scientific knowledge. The aim of this emphasis was to help students understand that a scientific enterprise includes professional activities and social certification and dissemination. Students worked like scientists and tried to convince their friends to value for their scientific report. As a result, they internalized the categories of professional activities and social certification and dissemination in RFN by doing them in the class. At the end of the lesson, students wrote what they learned on the "learned" part of the KWL chart. On the other hand, the control group was taught the characteristics of the Moon in the third lesson. However, they make an activity about life on the Moon individually not as a group. They determined and wrote the essential requirements to survive on the Moon. There was no emphasis on professional activities scientists engage in.

In the fourth lesson of experimental group, a research assistant from the Science Education Department of a university came to class and talk about his profession. He made a presentation about social-institutional part of his profession and engaged in a conversation with students. The researcher began his presentation by asking "What is science?". Then he showed some pictures of research centers and universities in which scientists work. After that, he discussed with students about what scientists need to accomplish their research. Finally, he talked about his profession, his relationship with other scientists and the conferences he engaged in. Students asked many questions. In this lesson, it was intended to make students aware of the social organizations, research centers, universities, national and international conferences scientists engage in. The guest didn't visit the control group class.

The fifth lesson's subject is the Moon phases. Both experimental and control groups were intended to learn main phases of the Moon. Both the experimental and control groups modeled Moon phases with given materials. Students in both groups modeled phases of the Moon by using many materials such as oreo biscuits, cardboard, crayons and plastic plate. However, only the students in experimental group exchanged their models with their desk mate and evaluated each other's model in certain criteria given by teacher. The detailed lesson plan for the experimental group can be found in Appendix H. The teacher in the experimental group told that scientists compare the results of their investigations with other works at conferences and events. Also, through the engagement of the scientific community, the scientific works get reviewed, criticized and evaluated (Erduran & Dagher). In this lesson, students realized that they engaged in a community to disseminate their scientific work like scientists do. Teacher also added that "dissemination of scientific knowledge involves collective and collaborative efforts of the community" (Erduran & Dagher, 2014, p. 141). The control group in the sixth lesson was expected to learn the Moon phases. They also modeled the phases of the Moon with given materials but they didn't engage in a peer evaluation activity. No emphasis was given on social certification and dissemination.

Experimental group's last lesson was "Moon Mining" includes almost all RFN's social categories as objectives but the prior category emphasized during the lesson was political power structure. First a reading text (see Appendix I) about Moon mining and Space mining was given to students. After reading, whole class discussed the Moon mining in terms of its financial aspects, political relations and ethics. Students became aware that many countries have been attempted to utilize space sources and there are many private companies developing the technologies to find and supply the space resources. At the other class hour, the teacher reflected a scheme that covers all the seven components of science as a social-institutional system on smart board (see Appendix I, Figure I1). Then, each component was discussed with whole class discussion.

3.4.2 Control group's instructions

Control group's first lesson is about the properties of the Sun. The teacher made a brainstorming on the Sun. Students told what they know about the Sun. Then, characteristics of the Sun were listed and discussed. In the second part of the lesson, the teacher asked about sunspots. The teacher gave detailed information about sunspots. What the sunspot is, how and why it occurs and when it appears. However, teacher didn't mention the relationship between the sunspots and economic crises. They were given only the properties of the Sun and sunspots. There was no emphasis on the concept of economy.

The curricular objective of the control group's second lesson is that students will be able to indicate the Sun's rotational movement. Students were taught the Sun is at the center of our solar system. The teacher taught the Copernicus's model of heliocentric system which says that the Sun, not the Earth, is the center of the solar system. Students in control group learnt Sun's rotational movement and as well as Galileo's contributions to the history of science but no emphasis was given on scientific ethos, social values and intellectual honesty. Students didn’t discuss the restrictions Galileo encountered in his life.

The third lesson of the control group was “Life on the Moon”. This lesson began with KWL strategy like in the experimental group. Students wrote what they know and want to know about the Moon. Then, teacher listed the characteristics of the Moon. Students worked individually not as a group. After that, students wrote individually what is needed to survive on the Moon. They determined and wrote the essential requirements to survive on the Moon. There was no emphasis on professional activities scientists engage in. At the end of the lesson, students wrote what they learned about the Moon on the “learned” part of the KWL chart. Moon landing video was not shown in the control group so students didn’t discuss the effect of politics on the development of science.

The subject of the fourth lesson in control group is the phases of the Moon. It was expected that the students will able to explain the relationship between the phases of the Moon and the Moon’s revolutionary movement around the Earth. Also they should be able to differentiate the main and intermediate phases of the Moon. For this reason, students modeled the phases of the Moon with given materials. They used many materials such as Oreo biscuits, cardboard, crayons and plastic plates. However, they didn’t engage in a peer evaluation activity like in the experimental group. No emphasis was given on social certification and dissemination. The control group’s last lesson is the summary of the structure and the characteristics of the Moon. The teacher told that there is a precious metal on the surface of the Moon but she didn’t mention the political power structures and financial systems. Thus, students did not think about the economical values of the Moon resources and competition among the states.

In a nutshell, the researcher of this study taught the students in both groups the same intended curriculum objectives. In both experimental and control group, the same instructional techniques were used. In the experimental group, the researcher administered to activities that are mainly based on social dimension of science framing with RFN. The instructions that were implemented to the experimental group emphasize the seven components of social-institutional part of the RFN while control group didn't include the social-institutional aspects of science.

3.5 Data analysis

The data obtained from Scientific Attitude Inventory (SAI) and Social-Institutional Questionnaire (SIQ) was analyzed by using SPSS software program. T-test was applied to pre-tests scores to see whether there are differences between the experimental and control groups in terms of students' understanding of social-institutional aspects of science and their attitudes towards science. The Analysis of Covariance (ANCOVA) was conducted because pre-existing differences were found in pre-test scores of the groups in both SAI and SIQ.

In order to analyze qualitative data, first the interviews were transcribed. Then, the core category was identified as "Science as a Social-Institutional System". The seven elements of science as a social-institutional system were determined as subcategories. After that, qualitative data was organized and presented under the corresponding subcategories. After the systematic coding process, researcher interpreted the findings.

Another qualitative data obtained from experimental group students' activity sheets was analyzed and interpreted by the researcher to find out students' level of development in term of understanding about social-institutional aspects of science. Students' performances on worksheets were assessed with rubric which was developed by the researcher. Airasian and Russell (2008) define rubrics as "A rubric is a set of clear expectations or criteria used to help teachers and students focus on what is valued in a subject, topic, or activity" (p. 223). Analytic rubric that assesses the seven categories of the social part of RFN as certain criteria was applied to four worksheets. It is important to write appropriate description of the performance. Thus, "None" was scored with 0 and it describes that student's responses cannot include the corresponding performance implicitly or explicitly. "Partial" means student's response includes the corresponding performance implicitly. In other words, a reader is able to infer the corresponding meaning from the response. "Complete" was scored with 4 and it means that student's response explicitly fulfill the corresponding performance.

Through the analysis of worksheets, how each student developed their understanding in term of social aspects of science was found. From the first activity to the last one, students' scores were compared and their development was interpreted. The evaluation rubric prepared for the Moon Mining worksheet is given as an example below Table 2. The complete evaluation rubrics can be found in Appendix J.

As can be seen in Table 2, rubric includes many items; some of them are related to RFN's social-institutional components while others are not. As in Table 2, each rubric has statements that measure students' understanding about the science concept. In other words, rubrics include not only RFN objectives but also lesson objectives because without learning the main scientific objective of the lesson, students cannot comprehend the importance of social-institutional aspects of science.

For example, in Table 2, the first two statements are related to understanding of what the Moon mining is and why it is important. Students should first meet these requirements. That's why, apart from the corresponding RFN objectives, rubrics also have lesson objectives. Additionally, the number of the RFN items was determined according to RFN objectives the lesson covers.

Table 2. Evaluation Rubric for Moon Mining Student Worksheet

	None (0 Pts)	Partial (2 Pts)	Complete (4 Pts)
Student was able to define "Moon Mining".			
Student was able to explain why space resources are so valuable.			
Student was able to express that states should work together on space mining for the benefit of mankind.			
Student was able to realize that people can do science to gain money.			
Student was able to know that states use science for political superiority and competition.			
Student was able to say that the Moon's environment can be damaged by Moon mining.			
Student was able to state that scientific studies are carried out in institutions like NASA.			
TOTAL SCORE			

CHAPTER 4

RESULTS

This chapter presents overall findings from the study described in the previous chapter. Firstly, the quantitative results were presented and organized by the following categories: Descriptive statistics and inferential statistics. These two topics also include two sub-topics that are: understanding of the social-institutional dimension of science and attitudes towards science. After quantitative results, qualitative results obtained from the experimental group students were presented in order to get a further insight into students' understanding. Qualitative results were given under the interviews and students' worksheets headings.

4.1 Descriptive statistics

Descriptive statistics were divided into two parts. First part includes analysis for understanding of social-institutional dimension of science. Second part is for students' attitudes toward science. Descriptive statistics (mean, min. and max values, standard deviation, skewness and kurtosis) were calculated to predict the characteristics of the distribution for control and experimental groups.

4.1.1 Students' understanding of social-institutional aspects of science

As can be seen in the Figure 3 and Figure 4, pre-SIQ scores of both experimental and control groups are normally distributed.

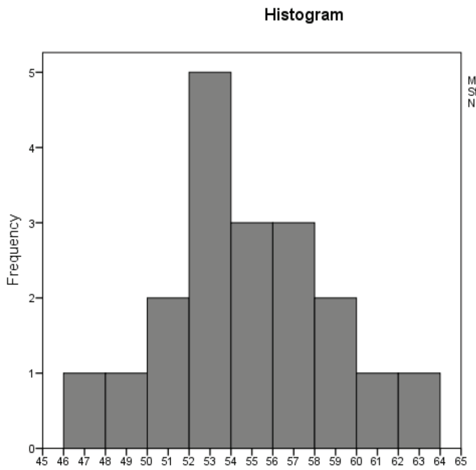


Fig. 3 Distribution of pre-SIQ scores for the experimental group

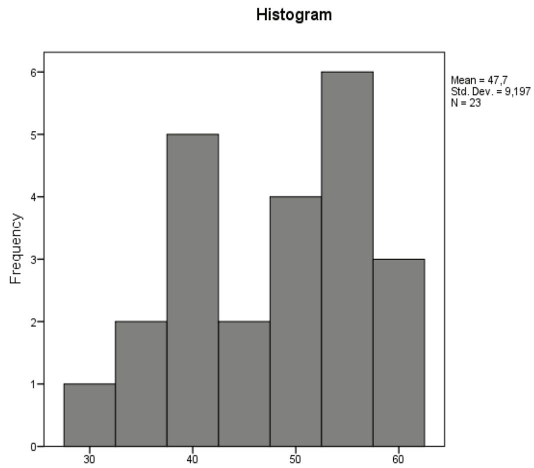


Fig. 4 Distribution of pre-SIQ scores for the control group

Table 3 shows the pre-test and post-test mean scores of students' results in social-institutional questionnaire (SIQ). The mean scores of post-tests for the students in the experimental group (M=62.63, SD=3.30) and in the control group (M=50.04, SD=7.39). According to Tabanchick and Fidell (2013), the acceptable range for skewness and kurtosis is between-1.5 - +1.5 values. Pre-SIQ scores of the experimental are normally distributed with the skewness of 0.181 and kurtosis of -0.203. Students' post-SIQ scores from both groups were found normally distributed with the skewness of -0.071 for the experimental group, 0.349 for the control group and the kurtosis of -0.584 for the experimental group, -0.995 for the control group.

Table 3.Descriptive Statistical Results of the Students' Pre-SIQ and Post-SIQ Mean Scores

Group	*Type of the Test*	*M*	*SD*	*Min*	*Max*	*Skewness*	*Kurtosis*
Experimental Group	Pre-SIQ	54.26	3.97	47	62	0.181	-0.203
	Post-SIQ	62.63	3.30	57	69	-0.071	-0.584
Control Croup	Pre-SIQ	47.70	9.19	30	60	-0.403	-1.146
	Post-SIQ	50.04	7.39	39	64	0.349	-0.995

According to Table 3, the experimental group's total mean score increased from M=54.26 to M=62.63 after intervention. Likewise, the control group's total mean score also increased from M=47.70 to M=50.04. Two groups' mean scores increased but inferential statistics analysis was used to determine whether these increases are statistically significant. The results will be given in the inferential statistics section.

4.1.2 Students' attitude towards science

The data collected from SAI pre-tests was tested to understand whether it is normally distributed or not. The pre-test scores of both experimental (M=139.26, SD=11.28) and control (M=130.78, SD=7.04) groups are normally distributed with respect to skewness and kurtosis values. Table 4 shows post-SAI mean scores for the students in the experimental group (M=144.63, SD=8.10) and in the control group (M=132.08, SD=8.03) for the SAI. The pre-test and post-test scores of both experimental and control groups are normally distributed with respect to skewness and kurtosis values that found in acceptable range (above -1.5 under +1.5).

Table 4. Descriptive Statistical Results of the Students' pre-SAI and post-SAI Mean Scores

Group	*Type of the Test*	*M*	*SD*	*Min*	*Max*	*Skewness*	*Kurtosis*
Experimental Group	Pre- SAI	139.26	11.28	118	155	-0.110	-0.973
	Post-SAI	144.63	8.10	132	162	0.672	-0.008
Control Croup	Pre- SAI	130.78	7.04	120	146	0.256	-0.630
	Post-SAI	132.08	8.03	122	146	0.571	-1.146

In accordance with Table 4, the experimental group's total mean score increased from M=139.26 to M=144.63 after intervention. Similarly, the control group's total mean score also increased from M=130.78 to M=132.08. Two groups' mean scores increased but inferential statistics analysis was used to determine whether these increases are statistically significant. The results will be given in the next section.

4.2 Inferential statistics

Both SIQ and SAI were administered to students as a pre-test before treatment and it was found that there is a significant difference between students' tests scores for both tests as a result of t-test. Therefore, analysis of covariance (ANCOVA) was applied for both tests in order to control pre-existing differences between the groups while comparing the groups. Then, posttests scores were compared between groups. Statistical results will be given in the next section.

4.2.1 Students' understanding of social-institutional aspects of science

The first research question was investigated in this part. The corresponding research question is:

> RQ1: What is the effect of teaching science as a social-institutional system on 5th grade students' understanding about social institutional aspects of science when compared to traditionally designed science instruction?

The data collected from SIQ was tested to understand whether it is normally distributed or not. In order to apply parametric tests, it is assumed that each sample should be normally distributed (Pallant, 2010). As seen in Table 3, pre-SIQ scores of the experimental are normally distributed with the skewness of 0.181 and kurtosis of -0.203. On the other hand, pre-SIQ scores of the control are normally distributed with skewness of -0.403 and kurtosis of -1.146. Therefore, parametric tests can be applied.

T-test was administered to two groups' pre-tests scores to see whether there is a significant difference between the groups. As a result of this analysis, statistically significant mean difference was found between the control group (M=47.70, SD=9.19) and the experimental group (M=54.26, SD=3.97); $t(31)=3.09$, $p= 0.004$. That's why, analysis of covariance (ANCOVA) applied to compare the post-SIQ mean scores by controlling the effect of pre-SIQ mean scores. Students' pre-SIQ mean scores were selected as "covariate".

Before the analysis, seven assumptions of ANCOVA were tested. These assumptions are normality, homogeneity of variances, measurement of covariate, reliability of the covariate, correlations among the covariates, linearity and homogeneity of the regression slopes (Pallant, 2010). These seven assumptions were verified for SIQ. ANCOVA assumptions will be explained in detail below.

Assumption 1: Normality

One of the assumptions of the ANCOVA is normality. Students' post-SIQ scores from both groups were found normally distributed with the skewness of -0.071 for the experimental group, 0.349 for the control group and the kurtosis of -0.584 for the experimental group, -0.995 for the control group. These values are between the acceptable ranges (see in Table 3.). Thus, normality assumption was verified.

Assumption 2: Homogeneity of variances

On the other hand, it was checked whether the variances were equal. The assumption of homogeneity of variances was violated according to Levene's test for homogeneity of variances. Levene's test indicated unequal variances $p<.05$. That means variances are heterogeneous. Kocher (1974), Rheinheimer and Penfield (2001) concluded in their studies that the violation of the assumption of homogeneity of variances may not cause a serious problem if the sample sizes are close. In addition, since the covariate (pre-test scores) is normally distributed, it is a low probability that the ANCOVA test is affected by heterogeneous variances (Huitema, 1980).

Assumption 3: Measurement of the covariate

The covariate (pretests) was measured before the treatment as it should be. This assumption is verified.

Assumption 4: Reliability of the covariate

Before the study, the scale was administered to 136 5th grade students. The reliability of the test was checked by calculating Cronbach alpha using the SPSS. As a result of the reliability analysis, Cronbach Alpha coefficient was found as 0.62.

Assumption 5: Correlations among the covariates

It is needless to check the correlations among the covariates since there is only one covariate in this study.

Assumption 6: Linearity

Linearity as one of the considerations of the ANCOVA assumes that there should be a linear relationship between the covariate and dependent variables (Meyers, Gamst & Guarino, 2013). Scatter plots was used to test linearity in this study. When the scatter graph is examined in Figure 5, it is found that there is a linear relationship between the covariate (pre-test) and the dependent variable (post-test) since the slopes of the dots (r_1=.09 and r_2=.27) are similar.

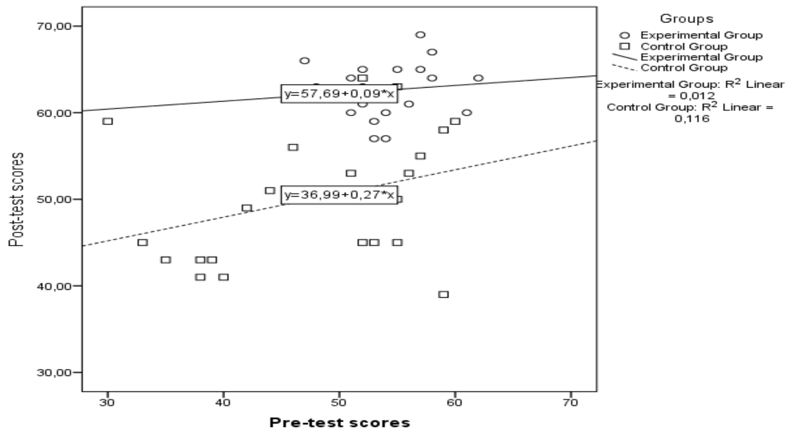


Fig. 5 Distribution of the pre-SIQ and post-SIQ scores for the experimental and control groups

Assumption 7: Homogeneity of regression slopes

Accoridng to the final, the relationship between the covariate and dependent variable should be the same for each of the group. Table 5 shows the statistical results for homogeneity of regression for post-SIQ scores. In order to test the homogeneity of regression, it should be looked for the sig. value in Group*TotalScore line in Table 5. Since p>.05, slopes of the regression lines are equal. That means homogeneity of regression assumption was verified.

Table 5. Statistical Results for Homogeneity of Regression for post-SIQ Scores

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1790,488[a]	3	596,829	18,034	,000
Intercept	766,276	1	766,276	23,153	,000
Groups	36,625	1	36,625	1,107	,299
TotalScore	32,756	1	32,756	,990	,326
Groups * TotalScore	8,207	1	8,207	,248	,621
Error	1257,631	38	33,096		
Total	133531,000	42			
Corrected Total	3048,119	41			

a. R Squared = ,587 (Adjusted R Squared = ,555)

All the seven assumptions of the ANCOVA was checked and verified. In conclusion, ANCOVA was applied in order to compare the post-test scores of experimental and control groups on SIQ while taking into account the covariate (pre-test scores).

As a result of the analysis (see in Table 6), a significant difference was found between the experimental (M=62.30) and the control group's (M=50.85) post-SIQ mean scores after controlling their pre- SIQ mean scores, $F(1, 39)= 31.78$, $p< .05$.

Table 6. A One-Way Analysis of Covariance (ANCOVA) Results for the post-SIQ Scores

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1782,281[a]	2	891,140	27,456	,000
Intercept	1539,280	1	1539,280	47,425	,000
TotalScore	133,539	1	133,539	4,114	,049
Groups	1031,527	1	1031,527	31,781	,000
Error	1265,838	39	32,457		
Total	133531,000	42			
Corrected Total	3048,119	41			

a. R Squared = ,585 (Adjusted R Squared = ,563)

This significant difference was found to be favor of students in experimental group. In other words, it was found that teaching science as a social-institutional system enhanced students' understanding on social and institutional dimension of science.

4.2.2 Students' attitudes towards science

The second research question of the study was investigated in this part. The corresponding research question is:

RQ2: What is the effect of teaching science as a social-institutional system on fifth grade students' attitude towards science?

T-test was administered to two groups' pre-SAI scores to see whether there is a significant difference between the groups at the beginning. As a result of this analysis, statistically significant mean difference was found between the control group (M=130.78, SD=11.28) and the experimental group (M=139.26, SD=7.04); t(29)=2.84, p= 0.008. That's why, analysis of covariance (ANCOVA) applied to control the initial differences between the groups before making comparisons between groups. Pre- SAI mean scores were selected as "covariate".

Before the analysis, seven assumptions of ANCOVA were tested. The data verified all the seven assumptions of ANCOVA including normality, homogeneity of variances, measurement of covariate, reliability of the covariate, correlations among the covariates, linearity and homogeneity of the regression slopes (Pallant, 2010). Detailed analysis of the assumptions was giving as follow.

Assumption 1: Normality

Experimental group students' post-SAI mean scores were found normally distributed with the skewness of 0.672 and the kurtosis of -0.008 (see in Table 4). Control group students' post-SAI mean scores were also found normally distributed with the skewness of 0.571 and the kurtosis of -1.146. These values are between the acceptable range (see in Table 4.). Thus, normality assumption was verified.

Assumption 2: Homogeneity of the variances

On the other hand, Levene's test was applied to test whether variances are equal. According to result of the analysis, $F(1,40)= 0.420$, $p>.50$ was found. In other words, the null hypothesis of equal variances is accepted. The variances are homogeneous.

Assumption 3: Measurement of the covariate

The covariate (pretests) was measured before the treatment as it should be. This assumption is verified.

Assumption 4: Reliability of the covariate

The test was administered to 300 students in 6th, 7th, 8th classes of primary schools by Demirbaş and Yağbasan (2006). As a result of reliability and validity analysis, Cronbach Alpha coefficient was found as 0.76, Spearman Brown Correlation was found as 0.84.

Assumption 5: Correlations among the covariates

It is needless to check the correlations among the covariates since there is only one covariate in this study.

Assumption 6: Linearity

The scatter plot was used to test linearity. When the scatter graph is examined in Figure 6, the straight lines were found. Although the lines are not parallel, their slopes are not too different. The interaction between the lines didn't violate the homogeneity of the regression slopes. The slopes of the lines are $r_1 = 0.1$ and $r_2 = 0.6$.

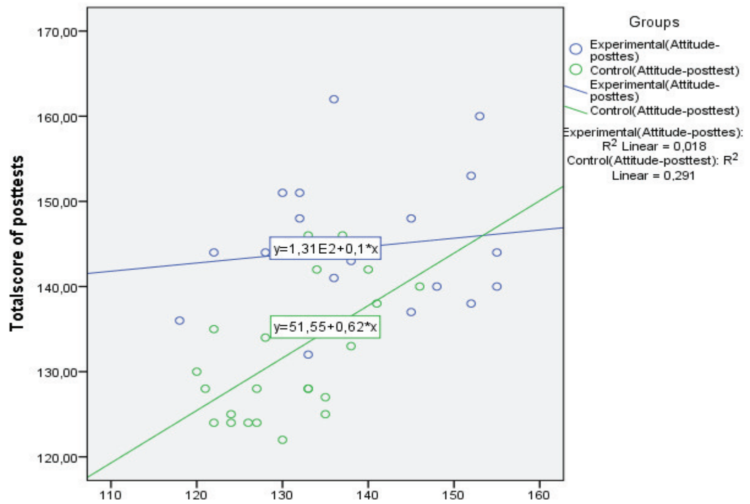


Fig. 6 Distribution of the pre-SAI and post-SAI scores for the experimental and control groups

Assumption 7: Homogeneity of regression slopes

The data was tested for homogeneity of the regression slopes and found that $p>.05$, slopes of the regression lines are equal. That means homogeneity of regression assumption was verified.

All the seven assumptions of the ANCOVA was checked and verified. In conclusion, ANCOVA was applied to post-SAI mean scores to find whether there is a significant difference between the experimental and control groups.

As a result (see in Table 7), it was found that there is a significant effect of teaching science as a social-institutional system on students' attitudes toward science after controlling their pre-SAI mean scores, $F(1, 39)= 14.89$, $p< .05$.

Table 7. A One-Way Analysis of Covariance (ANCOVA) Results for the post-SAI Scores

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1873,727[a]	2	936,864	15,430	,000
Intercept	1947,800	1	1947,800	32,081	,000
TotalPretest	236,355	1	236,355	3,893	,056
Groups	904,498	1	904,498	14,897	,000
Error	2367,892	39	60,715		
Total	801332,000	42			
Corrected Total	4241,619	41			

a. R Squared = ,442 (Adjusted R Squared = ,413)

This significant difference was found to be favor of students in experimental group (M=143.40) over the control group (M=133.10). In other words, it was found that teaching science as a social-institutional system enhanced students' attitudes toward science.

4.3 Qualitative results

Qualitative analysis of the data was done by analyzing experimental group students' activity sheets and audiotaped interviews. The experimental group students' activity sheets were assessed with an analytic rubric prepared by the researcher to see how students reflected related concepts to their activity sheets.

4.3.1 Interviews

The students' responses from the interview are given to concrete students' perception about social context of science after intervention. Each question in the interview refers one of the social-institutional categories in terms of RFN. Therefore, students' underlying concepts and thoughts will be reflected in this part. Qualitative analysis results show that some of the codes are related to each RFN category, and some of them are different. In this section, the findings of each category are discussed in the context of relevant codes and quotations.

- Professional activities

One of the question in the interview is "What do scientist do other than experimenting?". The codes such as "invention, publishing, making presentation" were found from the answers of this question. Two of the students answered this question by saying:

> They invent something and they write books. But… They do not do only science. They can do something else. For example, they can visit schools. They can prepare a presentation.
>
> They do not only do experiment, sometimes we see scientists on TV, scientists are researching, they are doing research like us. Scientists can visit schools and inform students.

Students emphasized that scientist can visit schools and make presentations. The possible reason of their answer will be discussed in discussion part.

- Social certification and dissemination

The questions "Imagine that you are a scientist and made a very important invention. What would you do to make everyone aware of this?"and "Is the work of scientists evaluated by other scientists?" were intended to reveal students' thoughts about social certifications and disseminations. Codes such as "evaluating, publishing, congress, meetings, consensus" were obtained from students' responses. Students' thoughts on this issue are as follows:

> Yes, scientists' work is evaluated by other scientists. Because maybe they found something wrong and they cannot prove it. Other scientists are investigating it and see if it is true.
>
> Yes, they build a consensus. They decide whether a work is good or bad.

- Scientific ethos

"Are scientist free?" In this question, all the three students stated that scientists are free. One of them told: "Scientists can be inspired from other scientists. it is not wrong to be inspired by someone else's thinking. They do not have to say only I am going to do this." This student's response given above includes the idea of scientific knowledge of collective and collaborative effort of the community as well as the universality of the scientific knowledge.

- Social values of science

Only one student explicitly mentioned animal rights by saying "He (scientist) should be careful not to kill the animal and sick or injure it". A few codes related to ethical rules could be obtained from the interview.

- Social organizations and interactions

"Where do scientists work?" Students responded this as "TÜBİTAK, NASA, research center, laboratories and universities." Only one student said: "Scientists can do science everywhere."

- Financial systems

In accordance with the students' responses, two of the students said that money is important to conduct a research whereas one of them said that money is not important and scientists can do science in any circumstances. One of the students said "Scientists need money to buy some products for their experiments." Another student who thought money is not important said "You do not need a lot of money to do science. Science can be done in any circumstances."

- Political power structures

All the students who interviewed expressed the presence of political power structures. One of them said: "…countries can compete with each other to go to the Moon. Like Japan and Russia ... For example, they can fight to become the first country which went to the Moon. Then they become enemies." It is understood that this student internalized one of the main objectives of "Moon Mining" lesson. The other two students implicitly mentioned the relationship between science and politics.

The most frequent codes in the students' responses from the interview are "Social Certification and Dissemination" and "Professional Activities". All the students in interview mentioned conferences and congress scientists engaged in. TUBITAK and NASA are the institutions students mentioned in the interview. As a response to the question "Can the work of scientists be evaluated by other scientists? How?", one of the students said "Yes, scientists come to a consensus and they discuss whether a scientific work is good or bad".

The least frequent codes in terms of RFN in the students' responses from the interview are "Scientific Ethos" and "Social Values". Only one student explicitly told animal rights by saying “He (scientist) should be careful not to kill the animal and sick or injure it”. The detailed interpretation of these trends will be given in the discussion part of this study. Some example responses and their corresponding codes in terms of RFN are given in Table 8 below. The quotes were taken from the responses which represent the social-institutional codes best.

Table 8. Example Questions, Responses and Related Codes in Term of RFN as a Result of Analysis of Interviews

Question	Sample Response	Related Code in terms of RFN
• Can countries use science to develop? How?	“For example, countries can compete with each other to go to the Moon. Like Japan and Russia ... For example, they can fight to become the first country which went to the Moon. Then they become enemies.”	Political Power Structures
• What do scientists do except for experimenting? Explain.	“Scientists do not only do science. They can do something else. For example, they can visit schools. They can prepare a presentation.”	Professional Activities
• Imagine that you are a scientist and develop something very important and valuable. What would you do to make everyone aware of this?	“I would apply to TUBITAK and went there. I would go there everywhere and show my work to them. I would make a presentation.”	Social Certification and Dissemination & Professional Activities
• What should a scientist who is experimenting with a drug on mouse regard?	“He should be careful not to kill the animal and sick or injure it.”	Social Values
• Where do scientists research?	“Scientists research in institutions like NASA…”	Professional Activities
• What do scientists need to accomplish their research?	“Money.”	Financial Systems
• Is a scientist free in his work?	“Scientists have to take permission from people before starting their research.”	Scientific Ethos

4.3.2 Students' worksheets

Students in experimental group were given activity sheets throughout the intervention and they collected the worksheets in a file belongs to themselves. An evaluation rubric was prepared by the researcher to evaluate students' understanding of social dimension of science. Rubric includes statements referred to seven components of social category of RFN. Students' responses were scored as "0" (none), "2" (partial) and "4" (complete).Some of the students' responses include more than one RFN social component so they were scored separately. In other words, one statement could be scored for more than one RFN component. After scoring, students' mean scores for each activity were found. No linear increasing was found. Conversely, students' scores decreased through the process of intervention. The scoring table can be found in Appendix J.

In accordance with the data that gathered from students' worksheets, some social categories of RFN are highly scored while others are not. After summation of all component scores, a gar graph was generated to see which components of social category of RFN were highly scored. Figure 7 shows that social certification and dissemination is the highest scoring component while social organizations and interactions is never mentioned component in the worksheets.

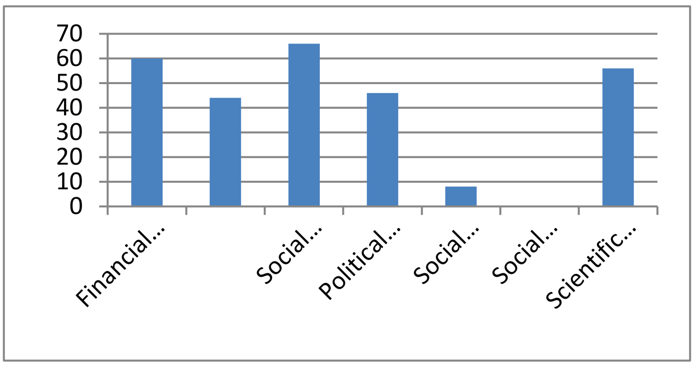


Fig. 7 Frequency of the scores in terms of RFN social categories

CHAPTER 5

DISCUSSION

This chapter has the discussion of the research results. Conclusions based on the study results, limitations of the study and recommendations for further studies are presented in the next section. In this section, the study results are discussed in detail in terms of students' understanding of the social-institutional aspects of science and their attitude towards science.

The current study investigated the effects of teaching science as social-institutional system on 5th grade students' understanding of social dimension of science and their attitude towards science. The study also presents students' underlying concepts about social dimension of science through interviews and worksheets.

The outcomes of the study indicated that the group instructed through the RFN's social-institutional perspective significantly outperformed the students instructed with traditionally designed science instruction in understanding the social-institutional aspects of science. The results also denoted that the teaching science as a social-institutional system enhanced experimental group students' attitudes towards science when compared with the control group students. The results of the study emphasized that teaching science as a social-institutional system was effective in enhancing the experimental group students' understanding of social dimension of science. This progress might be due to many factors.

Firstly, throughout the intervention, the experimental group students could be exposed to RFN's seven components of the social category. Each lesson includes discussion of these components. Especially in the last lesson, a scheme (see Appendix I, Fig. I1) that visualizes all the seven components of social-institutional category of RFN was demonstrated and discussed in class. This holistic image might help students to construct more comprehensive image of science in their minds. Also summarizing and discussing seven components which were learnt up to that time might reinforce their learning. According to results of a study, classroom discussions enhance students' comprehension and learning (Murphy, Wilkinson, Soter, Hennessey & Alexander, 2009). That's why; classroom discussion on social-institutional aspects of science may raise students' awareness of the social dimension of science.

Secondly, the visiting researcher's speech in the experimental group classroom might have an impact on students' understanding of science. Students could have a chance to meet a scientist and listen to his profession at first hand. In the interviews, all the three students indicate that scientists can visit schools and make presentations. The research assistant became an image of scientist for them. Actually, this application called as "scientists in the classroom" that refers to programs in which scientists visit to a classroom, give a presentation and discuss about their scientific expertise (Laursen, Liston, Thiry & Graf, 2007).These visits also increase students' interests and promote career goals on science. In this study, the visiting researcher talked about universities, research centers, research funds and congress in the class. In the light of this, it can be concluded that visiting researcher's presentation helped students understand the professional activities, social organizations and interactions, and scientific ethos easily.

Moreover, the most common code in the analysis of students' worksheet is social certification and dissemination (see in Fig. 7). Additionally, all students in the interview indicated that scientists' studies are evaluated and criticized by other scientists. This can be attributed to the experimental group's peer review activity in which students evaluated each other's Moon phase model. Actually, some students were reluctant to participate in the peer review activity because they didn't want to give low score to their classmates. In other words, they thought that criticizing their friends' model might cause resentment. Then, I explained that evaluation and criticism are supportive feedbacks and help scientists improve their work. Eventually, all students actively participated into activity. For these reasons, experimental group students enhanced their understanding of social certification and dissemination. On the other hand, students in both worksheets and interviews didn't emphasize on social values of science (see in Figure 7). This might be because of the fact that students are not mature enough to have sensitivity to the rights of others. When we look at the graph in Figure 7 it can be seen that, social institutions and interactions were also not emphasized adequately. The reason could be that paper-pencil responses cannot always reveal students' real thoughts.

Furthermore, throughout the intervention, it was observed that students were willing to participate in activities based on social dimension of science. Both experimental and control group were taught with the same instructional techniques but experimental groups' activities were enriched with the social category of RFN. The results are consistent with the Erduran and Dagher's (2014) statement that the inclusion of sociological and institutional context of science in science education is likely to increase engagement of students and enhance their interest.

More specifically, during the intervention, it was observed that the students are highly interested in discussing political, financial issues about science. The inclusion of the social-institutional aspects of science into science class enhanced students' attitude toward science and their understanding about social context of science. Before the intervention, students in experimental group had a little understanding about what scientists do in a social context. For example, the majority of the students thought that scientists can do science without money. Also, they thought that scientific works are not criticized by others. Students were not aware of the institutions scientists work together in. Interviews revealed that students became aware of the scientific institutions after intervention. They answered the question of "Where do scientists work?" as TÜBİTAK, NASA, small research centers and universities in spite of the fact that students did not mention these institutions in their worksheets (see in Figure 7). This also proves that paper-pencil questions cannot always show students' real thoughts.

Besides, as a result of the analysis of students' worksheets, no progress was recorded in students' scores in worksheets. No linear increasing was found. Conversely, students' scores decreased through the process of intervention. In other words, students didn't mention social organizations and interactions in the last worksheet. That made students' scores decreased. However, students used "NASA, TÜBİTAK, congress, research centers" words in interviews. Thus, instead of paper-pencil tests, interviews are more effective on revealing students' underlying thoughts.

On the other hand, the control group students also showed improvement in terms of the pre and post test scores in both SIQ and SAI but their improvement is not statistically significant. Their total mean scores increased after four weeks instruction. This improvement can be attributed to a number of factors. Firstly, students didn't know the instructor at the beginning and they might have a prejudice against the instructor so it is possible that students might fill the pre-tests under the bias of negative thoughts. As time progresses, they might develop positive relationship with the instructor and this might change their attitudes and affect their post-SAI scores. The instructor effect can be considered as confounding variable. In addition, despite the short duration of the experiment, the difference between pre-tests and post-tests in the control group may be due to the history.

In a nutshell, based on the results of this study, it can be concluded that the inclusion of the social-institutional aspects of science into science classes develop students' understanding about the social context of science. The study also provides evidence that teaching social dimension of science increases students' motivation and positive attitudes toward science.

My role as a teacher-researcher

My role as a researcher in the classroom is a teacher. I took on the role of teacher with great involvement of the process. As Bissex said in 1986 "Anyone can observe children but the teacher-researcher observes with an informed-eye" (p. 482), I observed students and got information from first-hand. Firstly, I didn't know the children before the intervention because it was the first year of the students at the school. Therefore, it is a low possibility for me to have bias about students in both experimental and control groups. Throughout the intervention process, I made great efforts to treat both groups equally. I tried to answer their questions with the same manner and teach the same scientific concepts.

There can be many advantages of being teacher-researcher. One of the advantages of being teacher-researcher is that teacher's experiences can affect his/her research topic. I as a teacher encounter many problems in education so it can be said that I am in the best position to generate research questions and make investigations and reflect the intervention process. Based on my experience, I realized that students are very willing to engage in classroom discussions about social context of science. Thus, my experience affected my research topic.

Another important issue about being teacher-researcher noted by Applebee (1987) that teachers and researchers see education from different perspective because they have different training and experience. I conducted this study from both researcher and teacher perspective. This study gave me an opportunity to apply an educational theory in a naturalistic setting. It is not always easy to put a theory into practice. Researchers can encounter many variables they didn't take into account. I could predict the problems and take precaution since I am familiar with the environment in which the study conducted. For example, at the beginning of the intervention, I distributed a file to each student in the experimental group so that they can keep their worksheets in it. Otherwise, I know most of the students will lose their worksheets. This means that being teacher-researcher makes the researching process easier.

CHAPTER 6

CONCLUSION

6.1 Implications

Results of this study indicate that students in experimental group significantly improved their understanding of social-institutional dimension of science. The current study also contributed to the literature in that integration of social-institutional aspects of science into science education develops students' positive attitudes toward science when compared to traditional science instructions. As stated in the study (Driver et al., 2000), science education should provide students the understanding that science is a social practice.

The currents study also provides science teachers and curriculum developers a resource to prepare and apply instructions enriched with the social-institutional aspects of science. A study conducted in England found that when social context of science is included in science classes, teachers believed that students' self-confidence and sensitivity to the rights of others improve. (Levinson, Douglas, Evans, & Turner, 2001). For this reason, teachers might be willing to integrate seven components of RFN's social-institutional category. Besides, this research provides teachers pedagogical advices about which strategies and instructional techniques they should be use in lessons. Argumentation, peer review, K-W-L charts, group discussion, presentation are the techniques that facilitate learning of social-institutional aspects of science. As a result, this study filled the deficiency of experimental research in RFN and contributed to the science education literature.

6.2 Future research

This study contributes to the research on RFN in science education by using a quasi-experimental research design. In order to see the effect of a NOS perspective in an experimental setting, instructions should be enriched with this perspective over a long time period such as one semester or one academic year. In the light of the results of this study, it can be suggested that further research is needed to investigate the effectiveness of teaching social aspects of science over a longer period of time on students' understanding of social context of science. Additionally, during intervention in this study, it was observed that students had difficulty to understand the concepts like "intellectual honesty" and "ethics". That's why, further research can be conducted with students in different grade levels especially in secondary school level because understanding of social-institutional dimension of science is required abstract thinking.

It is important to note that this is a small-scale quasi-experimental study conducted with small sample size. Although, the results can be generalized, one of the primary goals of this research is to determine a road map for science educators to show them how RFN can be integrated into science lessons. However, there are still not enough studies on how to apply RFN in science courses. For this reason, much more empirical study about RFN should be conducted.

APPENDIX A

SOCIAL-INSTITUTIONAL QUESTIONNAIRE (SIQ)

Class: **Gender:** **Age:**

Instruction: There are 15 statements on social and institutional aspects of science in this questionnaire. Please read these statements carefully and choose the option that best describes your idea. The options in the questionnaire are in the form of "Strongly disagree", "Disagree", "Neither agree nor disagree", "Agree" and "Strongly Disagree".

	Strongly disagree	**Disagree**	**Neither agree nor disagree**	**Agree**	**Strongly agree**
1. There is a relationship between science and money.					
2. Scientists examine and evaluate each other's work.					
3. Science is made in institutions like universities and research centers.					
4. Science emerges within a society.					
5. Politics influence science.					
6. Scientists should respect the environment.					
7. Scientist shares their research with the community.					
8. Scientists need money to do research.					
9. States influence the development of scientific knowledge.					
10. Scientist earns money through their work.					
11. Scientists' racial and ethical backgrounds influence their works.					
12. Scientists write articles in academic journals.					
13. Scientists participate in conferences to share their research with other scientists.					
14. Scientists must be honest.					
15. Scientists interact with other scientists socially while conducting research.					

APPENDIX B

SCIENTIFIC ATTITUDE INVENTORY (SAI) ITEMS

1. I like to study science.
2. Everything we need to know is accessible with science.
3. It is useless to listen to a new idea unless everybody agrees with it.
4. Scientists are always interested in explaining the events and objects around us.
5. If one scientist says an idea is true, all other scientists will believe it.
6. Only highly trained scientists can understand science.
7. We can always get the answers of our questions by asking a scientist.
8. Most people lack the ability to understand science.
9. Electronic products are examples of truly valuable products of science.
10. Scientists cannot always find answers to their own questions.
11. If scientists have good explanations about a scientific event, they do not need to improve it.
12. Most people can understand science.
13. Researching scientific knowledge can be boring.
14. Scientific work can be very difficult for me.
15. Scientists discover laws which tell us exactly what is going on in nature.
16. Scientific ideas can be changed.
17. The scientific questions are answered by observing the events and objects in the world.
18. Good scientists are willing to change their minds.
19. Some questions cannot be answered by science.
20. A scientist must have a good imagination to produce new ideas.
21. Ideas are the most important results of science.
22. I don’t want to be a scientist.
23. People have to understand science because science affects their lives.
24. A major purpose of science is to produce new drugs and save lives.
25. Scientists should report what they observe.
26. If a scientist cannot answer a question, another scientist cannot, too.
27. I want to work with other scientists to solve scientific problems.
28. Science tries to explain how things are happening.
29. Every citizen must understand science.
30. I may not be able to make great discoveries, but dealing with science can be fun.
31. One of the most important aims of science is to help people live better.
32. Scientists should not criticize their work.
33. The senses are one of the most important tools a scientist has.
34. Scientists believe that nothing is known to be true for sure.
35. Scientific laws have been proven beyond all possible doubt.
36. I want to be a scientist.
37. Scientists do not have enough time for their families or for fun.
38. Scientific studies are only useful for scientists.
39. Scientists have to work hard.
40. Working in a science lab can be fun.

APPENDIX C

INTERVIEW QUESTIONS

1. What comes to your mind when I say “science”?

2. Where do scientists research?

3. Can the work of scientists be evaluated by other scientists? How?

4. What do scientists need to accomplish their research?

5. Can countries use science to develop? How?

6. Is a scientist free in their work? If not, what are the rules that scientists follow?

7. Imagine that a scientist uses animals in laboratory experiments. What should this scientist pay attention to?

8. What do scientists do except for experimenting? Explain.

9. Imagine that you are a scientist and develop something very important and valuable. What would you do to make everyone aware of this?

APPENDIX D

EXPERIMENTAL GROUP'S LESSON SCHEDULE

	Subject	Objectives (MEB, 2017)	Activities	RFN Objectives Erduran & Dagher (2014)
1st Week (4 class hours)	The Structure of Sun and Its Characteristics	F.5.1.1.1. Students will be able to reveal the properties of the Sun. a. The geometric shape of the Sun is told. b. It is mentioned that the Sun is in the gas structure. c. It is stated that the Sun makes a rotational motion..	Sunspots and (Financial Systems) Galileo (Social Values & Scientific Ethos)	-Students will be able to realize the financial dimension of science. -Students will be able to recognize ethical practices such as intellectual honesty, respect for the environment, freedom and openness.
2nd Week (2 class hours)	The Structure of Moon and Its Characteristics	F.5.1.2.1. Students will be able to reveal the Moon's features.. a. The size of the Moon is told. b. It is mentioned the Moon's geometric shape. c. Information about the surface of the Moon is given. d. It is mentioned the Moon's atmosphere. F.5.1.2.2. Students will be able to discuss the ideas of life on the Moon.	Life in the Moon (Professional Activities)	-Students will be able to think that science and technology are linked to governments and states. -Students will be able to recognize that scientists engage in professional settings such as attending conferences.

3rd Week (6 class hours)	The Phases of the Moon	F.5.1.3.1.Students will be able to explain the Moon's rotational and revolutional movement a. It is stated that the Moon makes rotational motion. b. It is stated that the Moon makes revolutional movement. c. The concept of Moon is mentioned in terms of time. F.5.1.3.2. Students will be able to explain the relationship between the phases of the Moon and the Moon's revolutionary movement around the Earth a. Students will be able to determine the differences between the main and intermediate phases of the Moon. b. Students will be able to tell the phases' name chronologically. c. Students will be able to state that the period between the two main phases of the Moon in one week.	A Guest: Researcher from the Science education department. (Professional Activities, Financial Systems) Moon Phases (Social Certification and Dissemination)	-Students will be able to realize that scientists review, evaluate, and validate scientific knowledge.
4th Week (4 class hours)	Sun, Earth and Moon's Move Relative to Each Other	F.5.1.4.1. Students will be able to create a model of the Sun, Earth and the Moon representing their movements relative to each other. a. The direction of the Earth's revolution around the Sun is stated. b. The direction of the Moon around the Earth is stated. c. Students will be able to state that only the one side of the Moon is visible from Earth.	Moon Mining (Political power structures, Financial Systems, Social Interactions and Organizations, Social Values, Scientific Ethos, Professional Activities)	-Students will be able to express that scientists work in institutions like universities, research centers and industrial sites. -Students will be able to recognize that formulating and evaluating scientific claims need a set of norm.

APPENDIX E

SUNSPOTS / LESSON PLAN

Activity: Sunspots

Grade Level: 5

Unit: F.5.1. Sun, Earth and Moon

Objectives: F.5.1.1.1. Students will be able to explain the properties of the Sun (MEB, 2017).

RFN Objectives:

Financial Systems: Students will be able to think that there is a relationship between science and the economy. They will also be able to recognize the financial dimension of science.

Lesson Design

Part 1: Introduction to the Sun (15 minutes)

Part 2: Brainstorming (15 minutes)

Part 3: Sunspots (20 minutes)

Part4: Activity and Discussion (30 minutes)

Instructional Technique:

Brainstorming

Group Discussion

Prerequisite: None

Lesson Duration: 80 minutes

Part 1: Introduction to the Sun

- Ask students the question: What do you know about Sun?
- Then, explain the main characteristics of the Sun as listed below:

• Sun is a star. Its diameter is 100 times bigger than the diameter of Earth. He's on gas.

• Its structure consists of Helium and Hidrogen gases.

• The source of energy is the conversion of hydrogen atoms to Helium at very high temperatures and pressures.

• The temperature on all sides is not the same.

• The source of all the energies in the world is the Sun.

Part 2: Brainstorming

Brainstorming: Have students brainstorm about what they think a sunspot is. Students may have different ideas about sunspots so each idea should be listed on the board. Remind the students that no idea is pointless. All ideas will be welcomed. Encourage students to generate different ideas and ask:

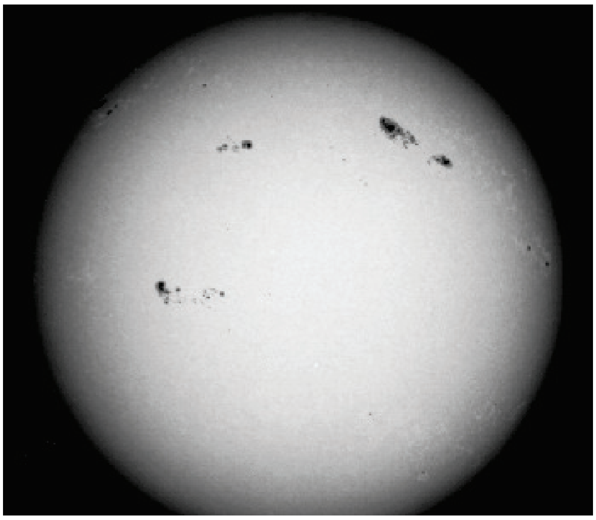
What is sunspot?

Note: If students do not know brainstorming, explain what it is and make an exercise before the real brainstorm. For example, make a brainstorm about the concept "winter".

Part 3: Sunspots

- Give the students worksheets
- In this section, information about the sunspots is given. Teacher explains, students follow from the students' worksheet.

Sunspots are temporary events that occur on various layers of the sun. These events that occur on the photosphere are not visible. The reason for the darkness of the sunspots is that the surface on which the stains are located is lower than the temperature around the sunspots. Numerically speaking, the sun's surface temperature is on average 5000 ° C. The temperature of the sunspots is 4000 ° C on average. The sizes of the stains are different.



This image will be reflected on the board.

Image 1.Sunspots (Erinç, 1957)

Observation of Sunspots

The number of sunspots has been recorded through different methods throughout history. The most used of these is observing the day through the use of the telescope and recording the number of stains on the surface of the Sun in the form of daily, monthly and yearly averages. The observations of sunspots at the telescope started in the 17th century. Information from previous periods has been determined by looking at the tree rings.

There is a relationship between number of sunspots and Earth climate.

In a research, it was stated that during the periods when the sunspots diminished, there was a decrease in temperature, an increase in precipitation. When sunspots grew, an increase in temperature and a decrease in precipitation have been observed (Erinç, 1957).

The number of sunspots increased during the following periods:

• Milano first got 3000-1600,

• BC 100-M.S.300,

• M.S. 800-1300 (Medieval Warm Season) and

• 1850-2000 (Global Warming Period)

In parallel with this, the temperatures have increased and the glaciers have been tapered and thinned (Özdemir & Bozyurt, 2004).

The number of sunspots decreased in the following periods:

• BC 1600-200,

• M.S. 300-800 and

• 1350-1850 (Small Ice Age)

During these years temperatures have fallen, glaciers have thickened and progressed (Özdemir & Bozyurt, 2004).

Part 4: Activity and Discussion

- Divide students into groups of 4 people.
- In this part, students will think on a scientific claim. This claim is:

"British economist William Stanley Jevons said in 1870 that there was a relationship between sunspots and economic crises." (Carlos & Shaffner, 1934).

- First, introduce students with this scientific claim.
- Then, want students to think about this claim individually and write the most possible explanation for this claim with the help of the reading text given in the student worksheet. Emphasize that there should be a cause and effect relationship in their explanation. Explanations will be noted on the " Individual Explanation" part
- After individual work, want students to develop an explanation with group members. Emphasize that they should be come up with the conclusion by working cooperatively with group member. Tell students they should state good reasons to convince their group mates. All groups will try to predict the relationships between the sunspots and the economic crises.
- At the final part, each group will present their explanations with reasons in front of the class.
- After all group presentations, explain that sunspots affect climate. Climate change affects agriculture. As a result, economy is affected by the agriculture.

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Özdemir, M. A., & Bozyurt, O. (2004). Son 5000 Yıllık Dönemde Meydana Gelen Sıcaklık Salınımları ile Güneş Lekeleri Arasındaki İlişkiler. *Afyon Kocatepe Üniversitesi Sosyal Bilimler Dergisi*, *6*(1), 1-16

STUDENT ACTIVITY SHEET

Read the following reading text carefully and consider what we read when answering the questions in "Thinking and Discussion".

Sunspots

Sunspots are temporary events that occur on various layers of the sun. These events that occur on the photosphere are not visible. The reason for the darkness of the sunspots is that the surface on which the stains are located is lower than the temperature around the sunspots. Numerically speaking, the sun's surface temperature is on average 5000 ° C. The temperature of the sunspots is 4000 ° C on average. The sizes of the stains are different.

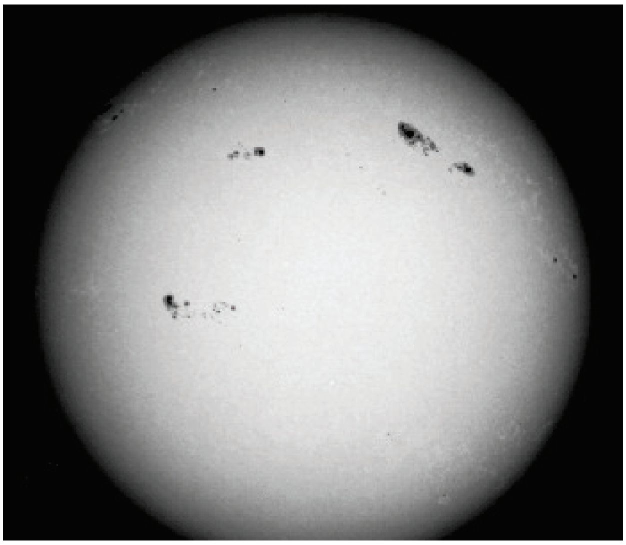


Foto 1. Günes Lekeleri

Observation of Sunspots

The number of sunspots has been recorded through different methods throughout history. The most used of these is observing the day through the use of the telescope and recording the number of stains on the surface of the sun in the form of daily, monthly and yearly averages. The observations of sunspots at the telescope started in the 17th century. Information from previous periods was determined by looking at the tree rings.

There is a relationship between the number of sunspots and the climate in the world. In the research that have been conducted, it has been stated that the temperature decreases in the decreasing periods of the sunspots, it increases in the temperature, increases in the temperature in the periods of increase of the spots, and decreases in the temperature (Erinç, 1957, p.145-150).

The number of sunspots increased during the following periods:

• BC 3000-1600,

• BC 100-M.S.300,

• AC. 800-1300 (Medieval Warm Season) and

• 1850-2000 (Global Warming Period)

In parallel with this, the temperatures have increased and the glaciers have been tapered and thinned.

The number of sunspots decreased in the following periods:

• BC 1600-200,

• AC. 300-800 and

• 1350-1850 (Small Ice Age)

Think and Discuss

British economist William Stanley Jevons said that in 1870, there was a relationship between sunspots and economic crises.

How can be a relationship between sunspots and economic crises? Explain first as an individual, taking advantage of the information given in the reading passage and establishing a cause-effect relationship. Develop a common statement with your teammates later. Write your thoughts in the gaps below.

Individual Explanation	**Group Explanation**

APPENDIX F

GALILEO / LESSON PLAN

Activity: Galileo

Grade Level: 5

Unit: F.5.1. Sun, Earth and Moon

Lesson Duration: 80 minutes

Objectives: F.5.1.1.1. Students will be able to explain the properties of the Sun and state that it has a rotational motion (MEB, 2017).

RFN Objectives:

- **Social Values of Science:** Students will be able to recognize ethical practices such as intellectual honesty, respect for the environment, freedom and openness.
- **Scientific Ethos:** Students will be able aware that scientific works can be restricted by ideological or religious constraints.

Lesson Design

Part 1: Warming Discussion (10 minutes)

Part 2: Life of Galileo(20 minutes)

Part 3: Galileo Experiment Video and Discussion (10 minutes)

Part 3 : Discussion of Social Values of Science (20 minutes)

Part 4: Intellectual Honesty (20 minutes)

Instructional Techniques:

Question- answer

Brainstorming

Prerequisite: Properties of the Sun

Lesson Duration: 80 minutes

Part 1: Introduction

- Tell the students that today they will discuss about an important scientist, Galileo.
- Ask students if they have heard Galileo before.

Part 2: Life of Galileo

- Give students reading text about Galileo’s life.
- Tell students to read the text carefully and underline the places they see as important.
- Reading text is available in appendix.
- After reading, show students Galileo experiment video available at: https://www.youtube.com/watch?v=E43-CfukEgs
- Discuss about the experiment. Ask:
  Why did a bowling ball and a feather drop together ?(Because there is no air in the room)

  Part 3: Discussion Social Values of Science
- Then discuss about the Galileo’s trial. Ask:
  Why was Galileo judged in court?
  What did the church protest?
- After a small discussion, explain that in history of science, many scientific works have been restricted by ideological or religious constraints as in the example of “The church defended the concept of an Earth-centered universe and found Copernicus theory to be contrary to the dyne.” And add that scientific studies cannot be thought apart from the society it emerges in. *(Scientific Ethos)*

Part 4: Intellectual Honesty

Brainstorming: Have students brainstorm about what they think honesty is. Students may have different ideas about honesty so each idea should be listed on the board. Remind the students that no idea is pointless. All ideas will be welcomed. Encourage students to generate different ideas and ask:

What is honesty?

Note: If students do not know brainstorming, explain what it is and make an exercise before the real brainstorm. For example, make a brainstorm about the concept “winter”.

Then, explain to students what the intellectual honesty is. Intellectual dishonesty often refers to lying to oneself. Copying another's work or original ideas are the examples of intellectual dishonesty. Some academicians copy the work of someone else without giving credit. Explain students the importance of giving reference and indicating the sources of information they use in their homework. Intellectual honesty is honesty in the using and interpreting of ideas. We should respect intellectual property. *(Social Values of Science)*

STUDENT ACTIVITY SHEET

Galileo Galilei

Galileo Galilei was born on 15 February 1564. He first began medical education, then turned into mathematics and philosophy. Galileo gave up medicine during his education at the University of Pisa and decided to work with philosophy and mathematics. In 1589 he became a professor of mathematics at the University of Pisa, in 1592 passed the University of Padua and remained here until 1610. At the age of 25, Galileo, a professor of mathematics, began experimenting on his own about movement from his early ages. He inspired by a simple telescope made in 1609, he developed superior telescopes and made observations about space that had never been done before.

Galileo adopted the solar-centered universe theory which Copernicus put forward before him, and for this reason he was tried twice by the Vatican Council. The church defended the concept of an Earth-centered universe and found Copernicus theory to be contrary to the dyne. In 1614, he was sentenced to life imprisonment in the first sentence of his teaching, forbidden to publish his views and to be prosecuted for a book he wrote in 1632. Because of these events, Galileo has become a symbol of the clash of science and religion in history.

In the 16th century the Polish Copernicus developed his own solar-centered universe model. Copernicus died 21 years before Galileo's birth. Galileo supported the Copernicus theory that the world was turning around the Sun, and this church had received a great response. The Church thought that this theory was contrary to the Bible's request for Josh to move to the Sun. Galileo in Roma was interrogated in front of the Inquisition. The Inquisition was convened and eventually they decided that Galileo's theory was unfounded and contrary to the truth. In 1616 Galileo supported and taught these theories and was banned by the church. When Galileo was executed, Galileo said, "I have not seen, I have not heard, and I do not know" to escape from death penalty.

APPENDIX G

LIFE ON THE MOON / LESSON PLAN

Activity: Life on the Moon

Grade Level: 5

Unit: F.5.1. Sun, Earth and Moon

Objectives: F.5.1.2.1. Students will be able to explain the properties of the Moon.

a. Students will be able to state the size of the Moon.

b. The geometrical figure of the Moon is mentioned.

c. Students will be informed about the surface structure of the Moon.

d. The atmosphere of the Moon is mentioned.

F.5.1.2.2. Students will be able to discuss the ideas about the life on the Moon. (MEB, 2017).

RFN Objectives:

Professional Activities: Students will be able to recognize that scientists engage in professional settings such as attending conferences.

Lesson Design

Part 1: Know of K-W-L (5 minutes)

Part 2: Want to Know of K-W-L (5 minutes)

Part 3: Properties of Moon(20 minutes)

Part 4: Moon Trip Video and Discussion (10 minutes)

Part 5: Life on Moon and Group Presentations (30 minutes)

Part 6: Learned of K-W-L(10 minutes)

Instructional Techniques:

K-W-L

Group Presentation

Prerequisite: None

Lesson Duration: 80 minutes

Part 1: Know of K-W-L

- Tell students that today's topic is Moon.
- Then give each student worksheet.
- Have each student complete the Know section of the KWL chart on his/her paper. Ask them to write under the title, *Know*, all the things they already know about the Moon.

Part 2: Want to Know of K-W-L

- Next, under the title, *Want to Know*, ask them to write down anything they want to know about the Moon.

Part 3: Properties of Moon

Tell the properties of the Moon and discuss each property with students. Want students to note these properties.

- It is the Earth's satellite.
- It has a global shape like the world.
- The size of the Moon is one fifth of the size of the Earth.
- It has no own light, it reflects the light from the Sun.
- The temperature difference between night and day is great. The temperature gates that go to 100C during the day fall below zero.
- From the moon, the sky looks dark because there is no atmosphere.
- The surface of the Moon is covered with gray sand and rocks.
- There are large pits called craters on the surface. These craters are the result of the big rocks circling in space hit the Moon.
- There is no water and air on the Moon.

Part 4: Moon Trip Video

- In this part, a 4 minutes video about Moon Trips will be shown.
- After watching the video, small discussion will be made with students.
- The video is available at : https://www.youtube.com/watch?v=lot81M9iisM
- Guided questions for after video discussion:
  How does the moon look in the video?

Why did some people persist in denying the Moon landing? (This question will reveal the relationship between science and political power structures. The **Apollo 11** mission was one of the most significant events in the Space Race between the United States and the Soviet Union.)
Would you want to visit Moon? Why or why not?

Part 5: Life on the Moon Activity

- Divide the class into groups of 4 students
- In this section, students will be given a scenario.
- According to scenario, students are supposed to be researchers working on space sciences. NASA will organize a huge international congress about survival on the Moon. The groups' task is to prepare a report about life on the Moon is possible or not. They will discuss with group members about what is needed to live on the Moon. They will determine and write the essential requirements to survive on the Moon. Then they will list the properties of Moon that are suitable and not suitable for life.
- Read the scenario aloud and explain what the students will do in detail.
- Emphasize that reports should include claims and evidence that support claims.
- Then, inform students that scientists engage in professional settings such as attending conferences.(*Professional activities).*They also review, evaluate, and validate scientific knowledge.(*Social Certification and Dissemination).*
- Define the congress: It means international meeting with people from the many countries to discuss any matter.
- Now, students will imagine themselves as scientist who are working with other scientist and share their findings in a congress.
- Tell students that at the end of the group working, each group will present their report in front of the class pretending they will made presentation in an international congress.
- Before starting group presentations, make an opening speech like "Welcome to First World Moon Congress! It is a great pleasure to see scientists all around the world!...."
- Each group will have 3 minutes for presentation.

Part 6: Learned of K-W-L

- Have each student complete the Learned section of the KWL chart on his/her paper. Call on students to share what they learned.

Reference: https://www.youtube.com/watch?v=lot81M9iisM

STUDENT ACTIVITY SHEET

Life on the Moon

Read the following scenario and answer the questions below as a group. Then write a report about survival on the Moon.

Scenario:

You are groups of researchers working on space sciences. NASA will organize a huge international congress about survival on the Moon. Your groups task is to prepare a report about life on the Moon is possible or not. Discuss with group members about what is needed to live on the Moon. Determine and write the essential requirements to survive on the Moon. Then list the properties of Moon that are suitable and not suitable for life. Next, you as a group will come up with a conclusion by taking into consideration the properties of Moon and present your report in World Moon Congress.

Your report should include claims and evidence that support your claims. You can use your lesson notes about the Moon as scientific information to support your findings. Form sentences like "People can live on the Moon, because scientists found that…………..."

1. What is needed to survive on the Moon?

2. What are the properties of the Moon that are suitable for life?

3. What are the properties of the Moon that are not suitable for life?

Report about Life on the Moon

Is It Possible?

APPENDIX H

MOON PHASES / LESSON PLAN

Activity: Moon Phases

Grade Level: 5

Unit: F.5.1. Sun, Earth and Moon

Objectives: F.5.1.3.2. Students will be able to explain the phase of the Moon and its relationship with the Moon's revolution around the Earth.

a. Students will be able to explain the differences among the main and intermediate phases of the Moon.

b. Students will be able to determine the names of the stages depending on the order of their occurrence.

c. Students will be able to state that the period between the two main phases of the moon is one week (MEB, 2017).

RFN Objectives:

Social Certification and Dissemination: Students will be able to realize that scientists review, evaluate, and validate scientific knowledge.

Materials: Carton papers in different colors, glue, scissors, Oreo biscuits, crayons, plastic plate and play dough.

Lesson Design	Instructional Techniques:
Part 1: Introduction (40 minutes)	Modeling
Part 2: Modeling Phases of Moon (40 minutes)	Peer Review
Part 3: Presentation (20 minutes)	**Prerequisite:** Properties of the Moon
Part 4: Peer Review, Reflection (10 minutes)	**Lesson Duration:** 120 minutes
Part5: Importance of Social Certification and Dissemination(10 minutes)	

Part 1: Introduction

- Tell students that today they will learn the different shapes of Moon. And ask the questions below to start a discussion:

Do you see the moon every evening?

Do you always see the moon the same way?

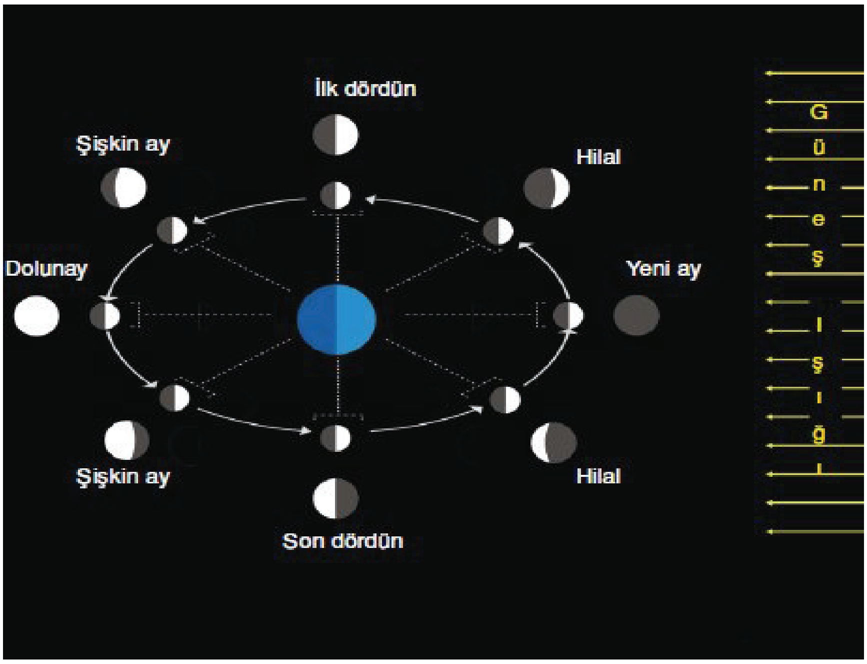
- Teacher will make the explanation given below. Students can take notes.

When we look at the night sky, we see the Moon in different forms. That's because the Moon is not a light source. If it were a light source, we would always look the same as the Sun. The moon reflects the light from the sun. The moon appears in different shapes depending on the place around the Earth.

The moon reflects the light from the sun. The moon appears in different shapes every night. This is called **the moon phase**. Each phase lasts about one week.

The phases of the moon starting with the New Moon are:

- New Moon
- First Quarter
- Full
- Third Quarter



This image will be reflected on the board and discuss on it. The image is also available in the student worksheet.

New Moon

When the Moon enters between the Sun and Earth, a new moon phase occurs. The Moon is not visible in the sky because the dark region of the Moon is facing the Earth.

First Quarter

After a week, the right side of the moon is the illuminated earth. The shape of the Moon is similar to the letter D.

Full Moon

A week later the world is in the middle of the Sun and Moon. The bright side of the moon looks at the Earth.

Third Quarter

After a week, the left side of the moon is the illuminated earth. The shape of the moon is similar to the inverted letter D.

Part 2: Modeling Phases of the Moon

- In this part, students will model phases of the Moon by using given materials.
- Want students to imagine they are scientists working on phases of Moon. They observe the Moon and collect data. Then, they need to model the phases. Given the material, each student will model their own phases of the Moon.
- Tell students that models will be evaluated by their classmates with certain criteria.

Part 3: Peer Review

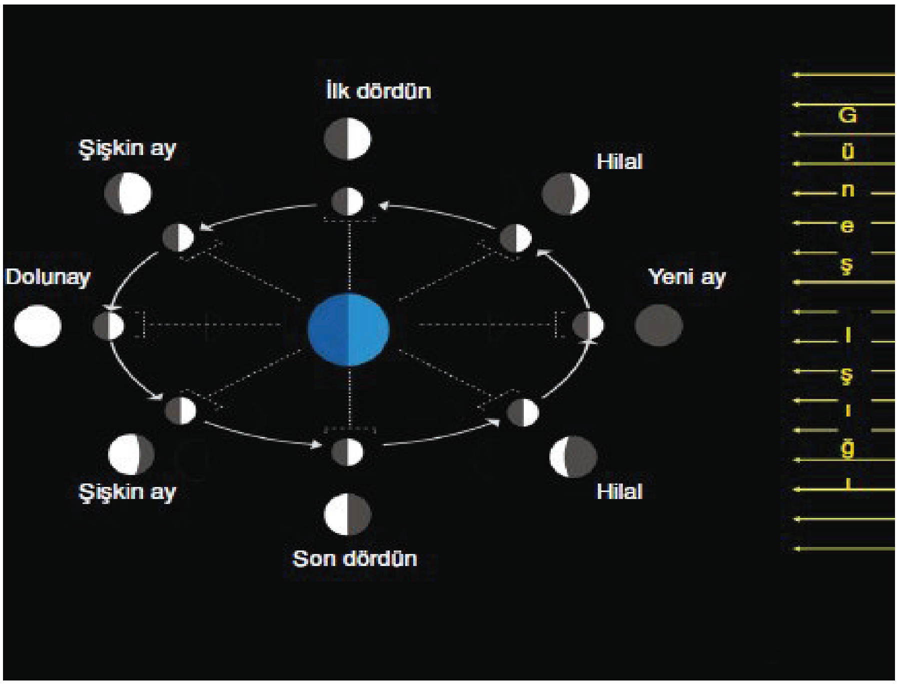
- After modeling activity, each student will exchange their models with desk mate and evaluate the model in certain criteria given by instructor. Evaluation scale is available in appendix.
- Then, 4 or 5 students will present their model, then their referee (desk mate) will comment about the model and say its' score.

Part 4: Importance of Social Certification and Dissemination

- Discuss with students about social certification and dissemination
- Explain that scientist compare the results of their investigations with other works at conferences and events. Through the engagement of the scientific community, the scientific works get reviewed, criticized and evaluated (Erduran & Dagher, 2014).
- In this lesson, students should be aware that they engaged in a community to disseminate their scientific work like scientists do.
- Emphasize that "dissemination of scientific knowledge involves collective and collaborative efforts of the community" (Erduran & Dagher, 2014, p. 141).

STUDENT ACTIVITY SHEET

Moon Phases



Evaluate Your Friend's Project!

Rating Scale

According to the criteria given in the table below, score your friend's moon phases model from 1 to 5. Then find the total score.

Criteria	Score (1-5)
Is the model scientific?	
Is the model suitable for the purpose of showing the phases of the Moon?	
Is the model creative?	
Is the model understandable?	
TOTAL SCORE:	

APPENDIX I

MOON MINING / LESSON PLAN

Activity: Moon Mining

Grade Level: 5

Unit: F.5.1. Sun, Earth and Moon

Objectives: F.5.1.2.1. Students will be able to explain the properties of the Moon (MEB, 2017).

RFN Objectives:

1. Students will be able to define science not only as an epistemic and cognitive system but also a social-institutional one.

Professional Activities: Students will be able to recognize that scientists working in social groups in social institutions such as NASA.

Social Organizations and Interactions: Scientists work in institutions like universities, research centers and industrial sites

Social Certification and Dissemination: Students will be able to discuss that scientists engaged professional activities such as attending conferences to present their work.

Scientific Ethos & Social Values: Students will be able to recognize ethical practices such as intellectual honesty, respect for the environment, freedom and openness and claim that formulating and evaluating scientific clams need a set of norm

Political Power Structures: Students will be able to think that science and technology are linked to governments and states, advancing for instance their colonial interests.

Financial Systems: Students will be able to realize the financial dimension of science and the commercial nature of science, scientific knowledge as a private property, science as a market and consumption of scientific knowledge to make profit.

Lesson Design	Instructional Techniques:
Part 1: Introduction (10 minutes) **Part 2:**Space Mining (20 minutes) **Part 3:**Whole Class Discussion(10 minutes) **Part 4:**Argumentation Activity (20 minutes) **Part 5:** Group Presentations (15 minutes) **Part 6:**RFN Wheel(5 minutes)	Whole Class Discussion Argumentation **Prerequisite:** Properties of the Sun, Earth and Moon **Lesson Duration:** 80 minutes

Part 1: Introduction

At the beginning of the lesson, give brief information about the relationship between political power structures and science by taking into consideration students' grade level. Explain as simple as possible. Tell that:

"Both science and technology have been historically linked to governments and states.

For example Galileo sharpened his telescope to see distant enemy better (Ferni & Bernardini, 2003).

Similarly, Heisenberg contributed to Hitler's scientific project (German Nuclear Weapon Project) for oppression and intimidation (Rose, 2002).

Werner Heisenberg

Adolf Hitler

Part 2: Space Mining

Throughout this lesson, emphasize the categories involved in the science as social and institutional system. These steps are identified in ***bold italic*** print throughout the Instructional Procedure Section.

- First, divide the class into groups
- Give the students reading text about space mining and asteroid mining (20 minutes to read).
- After reading, give brief information about space mining based on the text. *Moon and asteroids are rich with minerals that are rare on Earth. Therefore, some big companies and governments aim to remove these valuable minerals from space.*
- Ask the guiding questions, initiate a discussion and encourage your students to discuss.

Part 3: Whole Class Discussion

This lesson plan also contains the other categories of social-institutional aspects of science. Ask the questions below in order to reveal these categories.

1. Do astronomers and scientists work alone or within an organization or community? According to reading test, which institution does investigate space and other planets? ***(Social Organizations and Interactions)***

2. Do you know any other scientific institution like NASA in which many scientists work together? ***(Social Organizations and Interactions)***

3. In February of 2012, The Australian Centre for Space Engineering Research (ACSER) in Sydney organizes a meeting on "Searching for Mine" and brings together famous companies, scientists, engineers and robotic experts. *Why did many people from different disciplines meet? What could be discussed in this meeting?* ***(Professional Activities & Social Certification and Dissemination)***

4. *Who will benefit from these mines removed from moon or asteroids?* ***(Financial Systems)***

5. *Why is China and USA place importance on space mining?* ***(Political Power Structures)***

6. *Can space mining be dangerous? Can it harm the environment?* ***(Scientific Ethos & Social Values)***

Part 4: Argumentation Activity

- After discussion, want the groups to work together and answer the questions on the activity sheet. Want students to discuss the advantages and disadvantages of Moon mining with their group mates and then write their group idea with support from the reading text. First, they will express group claim like "Moon mining has many advantages" then support their claim by finding evidence from reading text like "Because it is written that………".
- It is important for students to justify their position. Emphasize the words "justify", "evidence", "support" and "claim".
- Groups will write the claim-evidence sentences on the table on the students' worksheet.
- Each group will write the advantages and disadvantages of space mining both on the worksheets and on post-its.

Advantages	Disadvantages

Part 5: Group Presentations

- Post-its will be sticked on the table on the board at this part.
- A spokesman from each group will present group's position with justification.

Part 6: RFN Wheel

- Finally, main features of science as a social institutional system will be summarized by using a visual representation (see Figure I1) proposed by the researcher.
- Teacher will summarize the social-institutional aspects of science.
- He / She will tell that scientists work in organizations like NASA with other scientists. Governments benefit from scientific works. People can get money from scientific projects. Also, it is important to consider ethical issues while doing science. Scientists should respect the environment.

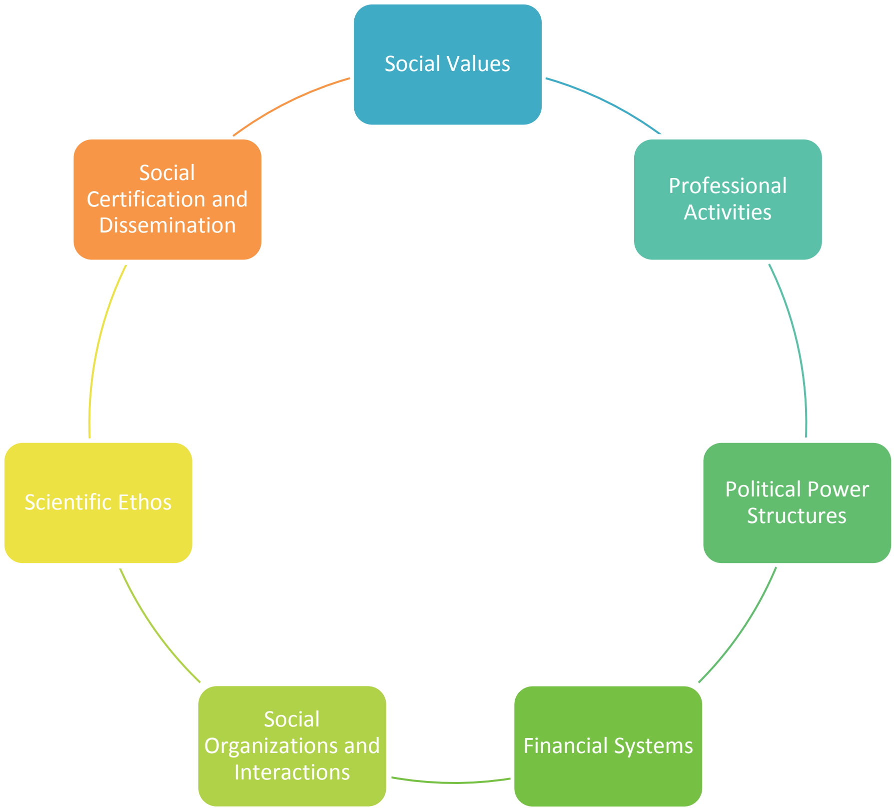
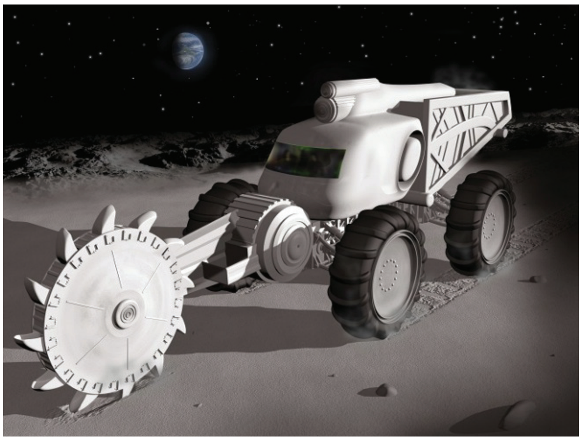


Fig. I.1 Science as a social-institutional system

STUDENTS ACITIVTY SHEET

Moon Mining

Read the following reading passage about Moon mining and answer the given questions on the sheet. Discuss the advantages and disadvantages of Moon mining with your groupmates. Then write your group idea with support from the reading text. First, express your group claim like “ Moon mining has many advantages”. Then support your claim by finding evidence from reading text like “ Because it is written that……….”



In the production of many devices such as mobile phones, computers, and car audio systems, raw materials used in the world are used in the future, so that many industrial raw materials can be experienced in the future. One of the possible solutions to this problem is to bring the materials that are rare in the world. For example, under the surface of the moon there are about 1.6 billion tons of mining reserves. It is also known that there is plenty of frozen water in the northern and southern poles of the Moon. That's why many space agencies and private companies are starting to make plans to utilize the reserves in the Moon.

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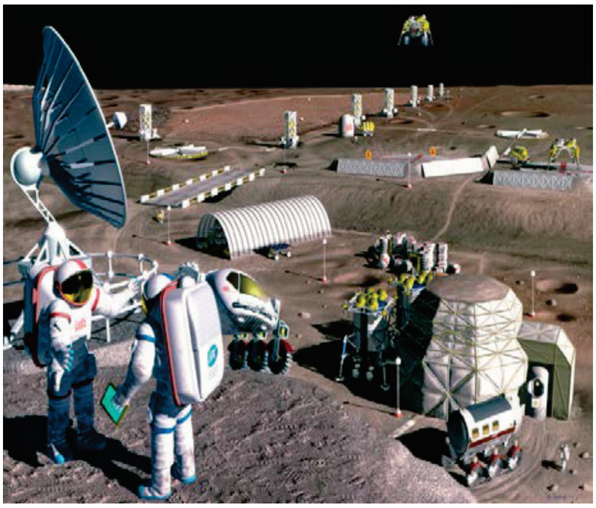
southern poles of the Moon. That's why many space agencies and private companies are starting to make plans to evaluate the reserves in the Moon.

Another company that plans to obtain fuel from the frozen water in the Moon is Moon Express. The company plans to produce fuel by converting frozen water to a chemical called "high-test peroxide" (HTP).

China is one of the countries that attach importance to mining activities in the Moon. In December 2013, this country made a significant leap in mining on the moon by lowering the Jade Rabbit named robot space vehicle to the Moon's surface.

Popular science writer Richard Corfield also discussed the mining issue on the Moon



in the last issue of Physics World. Corfield believes that space mining can be a first step in bringing people to other planets.

In February of last year, Australian Space For the first time in Sydney by the Engineering Center, "Beyond the World The meeting on "Searching for Mine" is the world famous mining companies, robotics experts, scientists working in space, engineers and various state institutions. All of them had one common goal: Space mining Project.

*This article was written by Özlem Kılıç Ekici and cited from *TÜBİTAK Bilim ve Teknik, September 2013, p. 30.*

- What is space mining?

- Why are the space resources so valuable?

- Do you think that governments should collaborate on space mining for humanity's benefit? Why?

Discuss with the group mates and write possible advantages and disadvantages of space mining.

Advantages	**Disadvantages**

APPENDIX J

EVALUATION RUBRICS FOR WORKSHEETS

1. Sunspots

RFN Objective: Students will be able to think that there is a relationship between science and the economy.

Score / Evaluation Criteria	None (0 Pts)	Partial (2 Pts)	Complete (4 Pts)
Scientific information has been used to support claims.			
There is a relationship between science and economy. (Financial Systems)			
In addition to individual explanations, the team explanations is also given.			
TOTAL SCORE			

2. Life on the Moon

RFN Objective: Students realize that scientists are engaged in professional activities such as participating in conferences, presenting papers, writing essays.

Score / Evaluation Criteria	None (0 Pts)	Partial (2 Pts)	Complete (4 Pts)
The student realizes that scientific researches are presented to other scientists in congresses.			
Instead of a "man of science", the student uses the expression of "scientist".			
The student realizes that the report being written is a product of a collective effort (He also writes the name of his groupmates)			
The student uses "we" instead of "I".			
The student supports his claim with scientific data.			
TOTAL SCORE			

3. Moon Phases

RFN Objective: Students will be able to realize that scientists review, evaluate, and validate scientific knowledge.

Score / Evaluation Criteria	None (0 Pts)	Partial (2 Pts)	Complete (4 Pts)
The student presents his project in front of the class by trying to convince his friends.			
The student evaluates his friend's project by taking into consideration the shortcomings.			
The student tolerates the criticism of his friend and teacher about his project.			
TOTAL SCORE			

4. Moon Mining

1. Students will be able to define science not only as an epistemic and cognitive system but also a social-institutional one.

Professional Activities: Students will be able to recognize that scientists working in social groups in social institutions such as NASA.

Social Organizations and Interactions: Scientists work in institutions like universities, research centers and industrial sites

Social Certification and Dissemination: Students will be able to discuss that scientists engaged professional activities such as attending conferences to present their work.

Scientific Ethos & Social Values: Students will be able to recognize ethical practices such as intellectual honesty, respect for the environment, freedom and openness and claim that formulating and evaluating scientific clams need a set of norm

Political Power Structures: Students will be able to think that science and technology are linked to governments and states, advancing for instance their colonial interests.

Financial Systems: Students will be able to realize the financial dimension of science and the commercial nature of science, scientific knowledge as a private property, science as a market and consumption of scientific knowledge to make profit.

Score / Evaluation Criteria	None (0 Pts)	Partial (2 Pts)	Complete (4 Pts)
Student was able to define "Moon Mining".			
Student was able to explain why space resources are so valuable.			
Student was able to express that states should work together on space mining for the benefit of mankind.			
Student was able to realize that people can do science to gain money.			
Student was able to know that states use science for political superiority and competition.			
Student was able to say that the Moon's environment can be damaged by Moon mining.			
Student was able to state that scientific studies are carried out in institutions like NASA.			
TOTAL SCORE			

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