INVESTIGATION OF SCIENCE TEACHERS' NATURE OF ENGINEERING VIEWS

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

NURSELİ İRDEM AĞRIMAN

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
SCIENCE EDUCATION IN MATHEMATICS AND SCIENCE EDUCATION

SEPTEMBER 2022

Approval of the thesis:

INVESTIGATION OF SCIENCE TEACHERS' NATURE OF ENGINEERING VIEWS

submitted by **NURSELİ İRDEM AĞRIMAN** in partial fulfillment of the requirements for the degree of **Master of Science in Science Education in Mathematics and Science Education Department, Middle East Technical University** by,

Prof. Dr. Halil Kalıpçılar
Dean, Graduate School of **Natural and Applied Sciences** ____________

Prof. Dr. Erdinç Çakıroğlu
Head of Department, **Math. and Sci. Edu.** ____________

Prof. Dr. Jale Çakıroğlu
Supervisor, **Math. and Sci. Edu., METU** ____________

Assoc. Prof. Dr. Sedef Canbazoğlu Bilici
Co-supervisor, **Math. and Sci. Edu., Gazi University** ____________

Examining Committee Members:

Prof. Dr. Ceren Öztekin
Math. and Sci. Edu., METU ____________

Prof. Dr. Jale Çakıroğlu
Math. and Sci. Edu., METU ____________

Assist. Prof. Dr. Mehmet Şen
Elementary Education, TED University ____________

Date: 02.09.2022

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Surname: Nurseli İrdem Ağrıman

Signature :

ABSTRACT

INVESTIGATION OF SCIENCE TEACHERS' NATURE OF ENGINEERING VIEWS

İrdem Ağrıman, Nurseli
M.S., Department of Science Education in Mathematics and Science Education
Supervisor: Prof. Dr. Jale Çakıroğlu
Co-Supervisor: Assoc. Prof. Dr. Sedef Canbazoğlu Bilici

September 2022, 77 pages

Today's, STEM education come into our lives and our curriculum. Therefore, STEM education that is the interdisciplinary approach and combine science with technology, mathematics and engineering is new trend in Turkey, so the especially, science teacher that are considered as an important part of STEM education should be good at engineering skills and know how to provide engineering training for students. Therefore, the views of teachers about nature of engineering is very important. In this study, the aim is to bring into open teacher's views about nature of engineering in central Anatolia in Turkey. Qualitative research method is utilized. Nine science teachers are participated in this study as a participant. Data were analyzed by using coding method. At the end of the study, teachers' views on nature of engineering differ in some points. In particular, the answers to the questions related to demarcation, engineering design process aspects vary. The teachers gave approximately the same answers to the questions asked for the tentativeness and creativity aspects. They thought that engineering design can change and engineering uses creativity and imagination. However, their reasons were also different. In the comments on the social and cultural embeddedness aspect, few participants thought that engineering is effected by society. Regarding the subjectivity aspect, the majority thought that engineering does not have a unique solution. Lastly, under social aspect of engineering, most teachers talk about engineers working as a group, but the answers to advantages and disadvantages differ.

Keywords: STEM, engineering, nature of engineering, science teacher

ÖZ

MÜHENDİSLİĞİN DOĞASINA YÖNELİK FEN ÖĞRETMENLERİNİN GÖRÜŞLERİNİN İNCELENMESİ

İrdem Ağrıman, Nurseli
Yüksek Lisans, Fen Bilimleri Eğitimi Bölümü
Tez Yöneticisi: Prof. Dr. Jale Çakıroğlu
Ortak Tez Yöneticisi: Doç. Dr. Sedef Canbazoğlu Bilici

Eylül 2022 , 77 sayfa

Günümüzde STEM eğitimi hayatımıza ve müfredatımıza girdi. Bu nedenle disiplinler arası bir yaklaşım olan ve bilimi, teknoloji, matematik ve mühendislikle birleştiren STEM eğitimi Türkiye'de yeni bir akımdır. Bu nedenle özellikle STEM eğitiminin önemli bir parçası olarak kabul edilen fen bilgisi öğretmenlerinin mühendislik becerileri ve mühendisliği nasıl uygulayacaklarını iyi bilmeleri gerekmektedir.Bu nedenle öğretmenlerin mühendislik algısı oldukça önemlidir. Bu çalışmanın amacı Türkiye'de İç Anadolu'da yaşayan fen bilgisi öğretmenlerinin mühendisliğin doğası hakkındaki görüşlerini araştırmaktır. Nitel araştırma yöntemi kullanılmaktadır. Bu çalışmaya dokuz fen bilgisi öğretmeni katılmaktadır. Veriler kodlama yöntemi kullanılarak analiz edilmiştir. Araştırmanın sonunda öğretmenlerin mühendisliğin doğasına ilişkin görüşleri bazı noktalarda farklılık göstermektedir. Özellikle sınır belirleme ve mühendislik tasarım süreci yönleri ile ilgili soruların cevapları çeşitlilik göstermektedir. Değişebilirlik ve yaratıcılık boyutlarına yönelik sorulan sorulara öğretmenler aşağı yukarı aynı cevapları vermişlerdir. Mühendislik tasarımının değişebileceğini ve mühendisliğin yaratıcılığı ve hayal gücünü kullandığını düşünmektedirler. Ancak bunun nedenlerine verilen cevaplar yine farklılaşmaktadır. Sosyal ve kültürel boyutuyla ilgili yapılan yorumlarda, mühendisliğin toplumdan etkilendiği düşüncesine çok az kişi sahiptir. Öznellik boyutuna gelince, çoğunluk mühendisliğin benzersiz bir çözümü olmadığını düşünmektedir. Son olarak, mühendisliğin sosyal yönü altında, çoğu öğretmen mühendislerin grup halinde çalışmasından bahsetmektedir. Ancak bu durumun avantaj ve dezavantajları için verilen cevaplar farklıdır.

Anahtar Kelimeler: STEM, mühendislik, mühendisliğin doğası, fen öğretmeni

To myself

ACKNOWLEDGMENTS

Firstly, I would like to express my most sincere gratitude to my supervisor Prof Dr. Jale ÇAKIROĞLU. I finished my thesis thanks to her support, being able to get answers to all my questions when I called her at any time of the day and making me believe that I could finish my thesis.

Secondly, I would like to express my sincere gratitude my co-adviser Assoc.Prof. Dr. Sedef CANBAZOĞLU BİLİCİ for her support and all suggestions.

I also would like to thank to my thesis committee members Prof. Dr. Ceren ÖZTEKİN and Assist Prof. Dr. Mehmet ŞEN for their suggestion.

I also would like to express deepest gratitude to my husband, Mustafa, for his support, suggestion, and love. Also, my full of love thanks go to my dear child, Deniz Ayaz. Thank you, my dear son, for waking up from your sleep every time I go to the computer to write a thesis, and for wanting to play with the computer every time you see me at the computer.

Finally, I would like to express most valuable thanks to my dear family, my mother Zeliha İRDEM and my father Ömer İRDEM. I couldn't have done anything without you. Glad you're my mom and dad. Also, I would like to thank my lovely sister, Selin YILMAZ, for her supporting.

TABLE OF CONTENTS

LIST OF TABLES

TABLES

LIST OF FIGURES

FIGURES

LIST OF ABBREVIATIONS

EDP	Engineering Design Process
NOE	Nature of Engineering
NOS	Nature of Science
STEM	Science-Technology-Engineering-Mathematics

CHAPTER 1

INTRODUCTION

1.1 Introduction

What is science? This question is actually difficult to answer because it has different definitions. According to Gilbert (1991), science is an operation that builds the estimated conceptual model. Moreover, according to the National Science Standards (NRC, 1996), science is a process in that students are active by making the inquiry, observing, testing, and constructing knowledge. Everything in daily life is related to science, so it plays an important role for us because it is in our daily life. According to Kola (2013), science education enhances students that are not members of scientific society to share the science content and to process with them, so we need to integrate it into our curriculum to familiarize this concept to students.

On the other hand, the science is not only enough to be taken from students because the connection between the other disciplines that are mathematics technology, and engineering is its inherent. According to Kola (2013), without science education, engineering, technology, medicine and the other disciplines are not possible to teach. However, according to Sanders (2009), science, technology engineering and mathematics have dominated in their fields for a century, and they are separated. On the other hand, the real-life that means thinking of without schools, designing and scientific inquiring interoperate with engineering to solve real life problems. For instance, when the mechanical engineer makes a car, they need to know science that enable the engineers the physical rules, mathematics to calculate what is necessary to make a car, technology to adjust modern-days, and, also, engineering to design the car different from others and develop its design ergonomically. In the light of these, we ought to think that these disciplines are not separate from each other.

According to White (2014), STEM education comes in view resulting lots of historical events such as World War II. In there, the science, technology, engineering, and mathematics are used to produce a new product that leads to improve STEM education. Another example of historical event is “Sputnik”. In view of White (2014), Sputnik pioneers to the beginning of STEM education because it leads the start of technological advance and technological achievement. Technological developments, achievements, increase in the workforce, and the replacement of human power with technological tools has caused some changes in education. As a result of these changes, the STEM approach began to be heard more in our curricula. According to Akgündüz et al. (2015) it must be necessary to raise a child that is interested in the field of STEM education, innovator, an entrepreneur, and think creatively because of making real in Turkey the miracle created in Japan, in South Korea, in Asia in the 2000s. Also, again according to Akgündüz et al.(2015) to raise these children, we need to an educational culture that gives responsibility, and computer programming from a very young age to students, makes them think, enables them to make wrong, and inoculates an entrepreneurial spirit, so if we ask the STEM is necessary for our culture, the answer will be YES. From the point of view of teachers, questions about engineering knowledge and how to apply it began to be asked because the teachers who give a STEM education that need to know engineering knowledge to students ought to know what engineering education is, and how to integrate it into our lessons. To answer the questions of how teachers’ engineering knowledge is and how is it applied, it is necessary to focus on the nature of engineering (NOE) because Karataş et al. (2011) stated that understanding the nature of engineering will lead to a better understanding of engineering and technology.To understand NOE well, it has been benefited from the nature of science to understand well the nature of engineering because in terms of Deniz et al. (2020), in science education, NOS is a well-established research field, so the historical trajectory of NOS scholarship in science education might enrich the evolving Nature of Engineering research agenda and attempts to define NOE ideas. Moreover, Deniz et al. (2020) conducted a study about it and stated that there is a relationship between them and according to , people can understand the creative, subjective, tentative, social, and socio-cultural dimensions of the scientific enterprise through contemporary NOS perspectives. Similarly, people who hold current NOE perspectives are also more inclined to value the creative, subjective, tentative, social, and sociocultural components of engineering design. On the part of Deniz et al. (2020) NOE aspects including demarcation, engineering design process (EDP), empirical basis, tentativeness, creativity, subjectivity, social aspect of engineering and social and cultural embeddedness were developed. Figure 1.1 and Figure 1.2 are tables about the descriptions of NOE aspects;

Figure 1.1: Description of nature of engineering aspects

NOE aspect	Description
Demarcation (What is engineering? What makes engineering different from other disciplines?)	Engineering is systematically engaging in the practice of design to achieve solutions for specific problems. Engineers apply their understanding of the natural world (scientific knowledge) to design solutions for real world problems
	In the K-12 context, "science" is generally taken to mean the traditional natural sciences: physics, chemistry, biology, and (more recently) earth, space, and environmental sciences…We use the term "engineering" in a very broad sense to mean any engagement in a systematic practice of design achieve solutions to particular human problems. Likewise, we broadly use the term "technology to include all types of human-made systems and processes-not in the limited sense often in schools that equates technology with modern computational and communications devices. Technologies result when engineers apply their understanding of natural world and of human behavior to design ways to satisfy human needs and wants (NRC 2012, pp. 11–12)
Engineering design process (EDP)	Engineering design process is viewed as both domain knowledge and the central practice of engineering in the Framework (NRC 2012). There is an overall agreement on the components of the engineering design process described below
	The core idea of engineering design includes three component ideas: Define, Design, and Optimize A. *Define* Defining and delimiting engineering problems involves stating the problem to be solved as clearly as possible in terms of criteria for success and constraints or limits B. *Design* Designing solutions to engineering problems begin with generating a number of possible solutions. These potential solutions are then evaluated to assess which ones best meet the criteria and constraints of the problem C. *Optimize* Optimizing the design solution involves a process in which solutions are systematically tested and refined and the final design is improved by trading off less important features for those that are more important (NGSS Lead States 2013, Appendix I, p. 104)
Empirical basis	Engineers optimize their design solutions and compare alternative solutions based on evidence obtained from test data
	… engineers engage in testing that will contribute data for informing proposed designs. A civil engineer, for example, cannot design a new highway without measuring the terrain and collecting data about the nature of the soil and water flows (NRC 2012, p. 45) Engineers use investigation both to gain data essential for specifying design criteria or parameters and to test their designs. Like scientists, engineers must identify relevant variables, decide how they will be measured, and collect data for analysis. Their investigations help them to identify how effective, efficient, and durable their designs may be under a range of conditions (NRC 2012, p. 50)
Tentativeness	Engineering design solutions are subject to change. Engineering design solutions can be revised to better achieve the desired goal or they can be revised to satisfy different criteria
	Phases of engineering design process do not always follow in order, any more than do the "steps" of scientific inquiry. At any phase, a problem solver can redefine the problem or generate new solutions to replace an idea that is just not working out (NGSS Lead States 2013, Appendix I, p. 104)

Figure 1.2: Description of nature of engineering aspects (cont'd)

NOE aspect	Description
Creativity	Creativity and imagination of engineers play a major role during the engineering design process. The role of creativity and imagination is not limited to any specific component of the engineering design process
	Engineering and science are similar in that both involve creative processes, and neither uses just one method (NRC 2012, p. 46)
Subjectivity	There is no unique solution to an engineering design problem. While there can be many solutions to the same problem, some of these solutions may be more suited to meet the criteria and constraints of the problem
	There is usually no single best solution but rather a range of solutions. Which one is the optimal choice depends on the criteria used for making evaluations (NRC 2012, p. 52)
Social aspects of engineering	Engineering is not a solitary pursuit. Engineering design solutions are constructed through social negotiation. Despite their individual differences, members of an engineering community share common understandings, traditions, and values. This social dimension enhances the quality of engineering design solutions
	The work of engineers, like the work of scientists, involves both individual and cooperative effort; and it requires specialized knowledge (NRC 2012, p. 28)
	Engineers cannot produce new or improved technologies if the advantages of their designs are not communicated clearly and persuasively. Engineers need to be able to express their ideas, orally and in writing, with the use of tables, graphs, drawings, or models and by engaging in extended discussions with peers. Moreover, as with scientists, they need to be able to derive meaning from colleagues' texts, evaluate the information, and apply it usefully. In engineering and science alike, new technologies are now routinely available that extend the possibilities for collaboration and communication (NRC 2012, p. 53)
Social and cultural embeddedness	Engineering is a human activity. There is a continued interaction between engineering and society. Sociocultural factors influence the engineering design process, and in turn, engineering influences the society. These social and cultural factors include social composition, religion, worldview, political, and economic factors
	Not only do science and engineering affect society, but society's decisions (whether made through market forces or political processes) influence the work of scientists and engineers. These decisions sometimes establish goals and priorities for improving or replacing technologies; at other times they set limits, such as in regulating the extraction of raw materials or in setting allowable levels of pollution from mining, farming, and industry (NRC 2012, p. 213)

Source: Deniz et al., 2020: 638 and 639.

However, Deniz et al. (2020) stated that there is a limitation about the empirical and social nature of engineering aspects that they defined in their study. Then, Kaya (2020) conducted a study including these aspects and different aspects from these aspects. Figure 1.3, Figure 1.4, Figure 1.5 and Figure 1.6 are tables about the descriptions of NOE aspects from the Kaya's study.

Figure 1.3: Description of nature of engineering aspects

NOE Aspect	**Description**
Demarcation (What is engineering? What makes engineering different from other disciplines?)	*Engineering is systematically engaging in the practice of design to achieve solutions for specific problems. Engineers apply their understanding of the natural world (scientific knowledge) to design solutions for real world problems.* In the K-12 context, "science" is generally taken to mean the traditional natural sciences: physics, chemistry, biology, and (more recently) earth, space, and environmental sciences…We use the term "engineering" in a very broad sense to mean any engagement in a systematic practice of design to achieve solutions to particular human problems. Likewise, we broadly use the term "technology to include all types of human-made systems and processes-not in the limited sense often in schools that equates technology with modern computational and communications devices. Technologies result when engineers apply their understanding of natural world and of human behavior to design ways to satisfy human needs and wants. (NRC, 2012, p. 11-12)

Figure 1.4: Description of nature of engineering aspects (cont'd)

Engineering design process (EDP)

Engineering design process is viewed as both domain knowledge and the central practice of engineering in the Framework (NRC, 2012). There is an overall agreement on the components of the engineering design process described below.

The core idea of engineering design includes three component ideas: Define, Design, and Optimize

A. Define: Defining and delimiting engineering problems involves stating the problem to be solved as clearly as possible in terms of criteria for success and constraints or limits.
B. Design: Designing solutions to engineering problems begin with generating a number of possible solutions. These potential solutions are then evaluated to assess which ones best meet the criteria and constraints of the problem.
C. Optimize: Optimizing the design solution involves a process in which solutions are systematically tested and refined and the final design is improved by trading off less important features for those that are more important (NGSS Lead States, 2013, Appendix I, p. 104)

Empirical basis

Engineers optimize their design solutions and compare alternative solutions based on evidence obtained from test data.

… engineers engage in testing that will contribute data for informing proposed designs. A civil engineer, for example, cannot design a new highway without measuring the terrain and collecting data about the nature of the soil and water flows (NRC, 2012, p. 45)

Engineers use investigation both to gain data essential for specifying design criteria or parameters and to test their designs. Like scientists, engineers must identify relevant variables, decide how they will be measured, and collect data for analysis. Their investigations help them to identify how effective, efficient, and durable their designs may be under a range of conditions (NRC, 2012, p. 50)

Tentativeness[1]

Engineering design solutions are subject to change. Engineering design solutions can be revised to better achieve the desired goal or they can be revised to satisfy different criteria.

Phases of engineering design process do not always follow in order, any more than do the "steps" of scientific inquiry. At any phase, a problem solver can redefine the problem or generate new solutions to replace an idea that is just not working out (NGSS Lead States, 2013, Appendix I, page 104).

Figure 1.5: Description of nature of engineering aspects (cont'd)

Creativity	*Creativity and imagination of engineers play a major role during the engineering design process. The role of creativity and imagination is not limited to any specific component of the engineering design process.* Engineering and science are similar in that both involve creative processes, and neither uses just one method (NRC, 2012, p. 46).
Subjectivity	*There is no unique solution to an engineering design problem. While there can be many solutions to the same problem, some of these solutions may be more suited to meet the criteria and constraints of the problem.* There is usually no single best solution but rather a range of solutions. Which one is the optimal choice depends on the criteria used for making evaluations (NRC, 2012, p. 52).
Social aspects of engineering	*Engineering is not a solitary pursuit. Engineering design solutions are constructed through social negotiation. Despite their individual differences, members of an engineering community share common understandings, traditions, and values. This social dimension enhances the quality of engineering design solutions.* The work of engineers, like the work of scientists, involves both individual and cooperative effort; and it requires specialized knowledge (NRC, 2012, p. 28). Engineers cannot produce new or improved technologies if the advantages of their designs are not communicated clearly and persuasively. Engineers need to be able to express their ideas, orally and in writing, with the use of tables, graphs, drawings, or models and by engaging in extended discussions with peers. Moreover, as with scientists, they need to be able to derive meaning from colleagues' texts, evaluate the information, and apply it usefully. In engineering and science alike, new technologies are now routinely available that extend the possibilities for collaboration and communication (NRC, 2012, p. 53).
Social and cultural embeddedness	*Engineering is a human activity. There is a continued interaction between engineering and society. Sociocultural factors influence the engineering design process, and in turn, engineering influences the society. These social and cultural factors include social composition, religion, worldview, political, and economic factors.* Not only do science and engineering affect society, but society's decisions (whether made through market forces or political processes) influence the work of scientists and engineers. These decisions sometimes establish goals and priorities for improving or replacing technologies; at other times they set limits, such as in regulating the extraction of raw materials or in setting allowable levels of pollution from mining, farming, and industry (NRC, 2012, p. 213)

Figure 1.6: Description of nature of engineering aspects (cont'd)

Criteria or Constraints	*Engineers make decisions based on predetermined criteria and constraints during the engineering design process. Making gains on one criterion often involves losing on another criterion or other criteria.* Engineers must contend with a variety of limitations, or constraints, when they engage in design. Constraints, which frame the salient conditions under which the problem must be solved, may be physical, economic, legal, political, social, ethical, aesthetic, or related to time and place. In terms of quantitative measurements, constraints may include limits on cost, size, weight, or performance, for example. And although constraints place restrictions on a design not all of them are permanent or absolute (NRC, 2012, p. 205).
Failure-Laden	*Failure in engineering design is inevitable and provides opportunities for improving design solutions. Engineers engage in multiple iterations to enhance the quality of their products and systems.* Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved (NRC, 2012, p. 207). Engineers often look for and analyze patterns, too. For example, they may diagnose patterns of failure of a designed system under test in order to improve the design (NRC, 2012, p. 86).

Source: Kaya, 2020: 194, 195, 196 and 197.

1.2 Significance of the Study

The importance of engineering has increased with the development of technology and the replacement of labor force by machines. In this direction, developed countries wanted to make some reforms in education. With the birth of the STEM concept, engineering was integrated into science courses. In our country, engineering has started to be included in the education process with some changes in the curriculum made in 2018 (Ministry of National Education [MoNE], 2018). The inclusion of engineering in education programs raises the question of what teachers know about this subject. In this study, it was aimed to collect information about teachers' views on the nature of engineering.

There are three main specific significance of this study. The first one is that studies on nature of engineering related to these aspects are limited. The fact that the study depends on these aspects reveals the value of this study and will contribute to the literature. Secondly, in the previous studies, it was taken views from elementary school teachers (Deniz et al.,2020) or preserve teachers or engineers educators (Kaya, 2020) about the nature of engineering. This study focused on middle school teachers' views about nature of engineering. The fact that there was no study related to these aspects at this level. It shows the importance of the current study. Finally, in the study conducted by Deniz et al., (2020), there was a limitation about empirical and social NOE aspects. Then, in study conducted from Kaya (2020), the new nature of aspects and new questionnaires were developed. In this study, the aspects of NOE taken from study (Deniz et al.,2020) from literatüre about nature of engineering views are adapted to Turkish and social aspect of NOE that are known as missing in this study are taken from the study (Kaya, 2020), and again adapted to Turkish. Closing the deficiencies in the first study with a question taken from the other study and applying it to different teachers in terms of experience is a feature that distinguishes the study from other studies. Moreover, the changes in questionnaires make a new contribution to the literatüre.

In conclusion, also, this study and previous studies have not only contributed to the literature, but also can guide the training programs to be applied to teachers according to the information obtained at the end of this study. With qualified teacher education programs, it can be developed for teachers to integrate engineering into their courses more consciously and to increase their knowledge level on this subject.

1.3 Definition of Important Terms

Nature of Engineering: According to Deniz et al. (2020), NOS is a well-established study topic in scientific education, therefore the historical trajectory of NOS scholarship in science education may enhance the expanding NOE research agenda and attempts to define NOE ideas. Furthermore, it has been discovered that there is a link between them, and according to Deniz et al.(2020), current NOS viewpoints can help people grasp the creative, subjective, tentative, social, and socio-cultural components of scientific discovery. People who hold contemporary NOE attitudes are also more likely to respect engineering design's creative, subjective, uncertain, social, and sociocultural components (Deniz et al., 2020).

STEM Education: Definition of STEM education is difficult because according to White (2014) it has different definitions based on different people. There are some different views about it. In view of Sanders (2009) "STEM education includes approaches that explore teaching and learning between/among any two or more of the STEM subject areas, and/or between a STEM subject and one or more other school subjects" (p.21.). In contrast to this definitions, in view of The United States Department of Education (2007), "Science, Technology, Engineering, and Mathematics education programs are defined as those primarily intended to provide support for, or to strengthen, science, technology, engineering, or mathematics (STEM) education at the elementary and secondary through postgraduate levels, including adult education."(p.11)

Science: In terms of Eastwell (2002), science is frequently referred to be one method of knowing, characterizing, categorizing, and comprehending our cosmos, notably in curricular materials.

Mathematics: According to Toluk (2003), in general, different definitions will emerge, such as the knowledge of numbers and shapes, the collection of operations and rules, the science of patterns and orders .

Technology: According to Günay (2017), Technology based on scientific knowledge, machine and knowledge of manufacturing devices.

Engineering: Engineering is a profession that seeks to provide solutions to client's technological issues (Hartman, 2016)

1.4 Purpose of the Study

The purpose of the study was to investigate and evaluate the views of science teachers' about nature of engineering. The innovations added to the curriculum, the introduction of STEM education into our lives, becoming importance of engineering education with STEM education necessitate to make this study. Developing countries try to develop or developed countries try to improve more and arrive necessities of their current age by making innovations, using technologies, making their designs, solving their problems by thinking or sharing their ideas with others. In fact, all these mentioned features reveal the importance of the concept of engineer, and it leads to some changes in education system. According to Cansoy (2018), it is seen that the expectations that are relating to the needed individual qualities have changed depending on the social, economic, political, and technological developments in the 21st century. In addition, these changes also affect the education systems, and some situations of making some necessary changes in the knowledge, skills and competencies are made out (Cansoy, 2018). Moreover, according to Akgündüz et al., (2015), with the globalization, leadership in field of economic success, technological development, and defense industry become more important day by day. Competitions of innovativeness between countries get bigger because of developments in the world and depletion of resources. Due to gaining speed of competitions of technological development, the countries feel obligate to bring improvement about educational policies (Akgündüz et al., 2015). Engineering practices have begun to be included in science education. In the light of these issues, in our country, Turkey, science, engineering, and entrepreneurship practices were integrated in the middle school science curriculum in 2018 (MoNE, 2018). The science, engineering and entrepreneurship practices aim to develop students' entrepreneurial, science and engineering skills. With this program, the student identifies a problem from daily life. They produces alternative solutions to this problem by considering its own material and vehicle situation. It is expected to choose the most suitable one among the alternative solutions. This produces a product with the chosen solution. They are expected to market their products to improve their entrepreneurial skills, and to develop strategies for this (MoNE, 2018). According to 2018 science curriculum in Turkey, these discipline assists students inventing and innovating solutions to issues from an interdisciplinary perspective by integrating science, mathematics, technology, and engineering, allowing students to make and use products using the knowledge and skills they have obtained, and it entails devising techniques for adding value. That is, it was aimed that students gain engineering skills in the light of interdisciplinary approach that includes science, mathematics, and technology. Also, engineering plays a direct role in problem resolution and innovation. According to Bybee (2010), students should study engineering and gain some of the skills and talents connected with the design process because of its economic value to society. When we look at all these, the importance of STEM (science, technology, engineering, and mathematics) education that are famous and added into educational policy has emerged. It is still new in Turkey, so science instructors, who are considered to become a significant element of STEM education, must have solid engineering knowledge, and know how to use it in order to deliver engineering education by integrating science, mathematics and technology. As a result, teachers' views on engineering are critical. As a result of these, the study's goal was to look into and analyze middle school science teachers views on the nature of engineering. In this study, aspects of the above-mentioned studies and related questions were taken as a basis in order to reveal the views of teachers. Some of the questions were removed or changed as a result of the pilot study. Then, the following research question guided the present study.

1.5 Research Question

What are the views of science teachers about the nature of engineering?

CHAPTER 2

LITERATURE REVIEW

In this chapter, it is mentioned definitions, general characteristics, emergence, importance, and studies about STEM education, definition, importance and studies about engineering, and the nature of engineering and studies about it.

2.1 STEM EDUCATION

With the change in the 2018 science curriculum, we heard more about STEM education. In this case, it revealed that more information should be obtained on this subject and that more work should be done. In this section, what is available in the literature about STEM education will be discussed.

2.1.1 Emergence of STEM education

The development of industry, the invading technology of our lives, and the depletion of resources have caused countries to seek innovation, and it is obvious that this can be possible with education and changes made in education, and The United States has been a pioneer in this regard, so it published a new curriculum in 1996 within the scope of the National Science Education Standard. (Akgündüz et al., 2015). The purpose of national science education standards in the US is to present to every student at different grade levels what they need to know, understand and be able to do in order to achieve scientific literacy (NRC,1996). This program, whose aim is to provide an inquiry-based learning experience, has found great response both in the USA and in developed and developing countries (Akgündüz et al.,2015). Later, it was aimed to deliver quality education to all components of the society and reports on this issue started to be published in the business world, but the reports started to put pressure on schools to increase the quality of the workforce and further develop the renaissance (Akgündüz et al., 2015). In the face of these pressures and demands, it was discussed that engineering education should be given in schools, and as a result, STEM started to become popular by considering engineering with other disciplines (science, mathematics, and technology) education (Akgündüz et al., 2015). In addition, there have been events that indirectly formed the infrastructure of STEM education, and these events are World War II and SPUTNIK (1957) mentioned before in the introduction part. (White, 2014).

As regards the birth of STEM education in Turkey, engineering and entrepreneurship practices were added to the science curriculum in 2018.

A definite answer to the question of what is a STEM has not been found yet. There are different opinions. According to Brown (2012), STEM (science, technology, engineering, and math) education research encompasses a wide range of topics with ambiguous criteria. That's why the definitions of STEM education can be diversified, so from the literature, there are different definitions for STEM education. STEM education is thought of as an approach in some studies. For example, Breiner et al. (2012) defined STEM education as an approach that contains teaching based on a traditional lecture that reinforces inquiry and project-based learning. Similarly, Özcan and Koştur (2018) stated that STEM is the combination of Science-Technology-Engineering-Mathematics. In addition to these, according to Hasanah (2020), STEM education was defined not only as an approach but also as a career, as instruction and field in studies. Otherwise, Gonzalez and Kuenzi (2012) define STEM education as the field of science, technology, engineering and mathematics and reference to teaching and learning. Moreover, in reference to Akgündüz (2018), STEM education refers to a process in which theoretical knowledge is practically transformed into a product. As a result of different definitions of STEM education from the literature, it can be understood that there is no single real definition of STEM education. That is, in terms of Brown (2012), while the precise concept of STEM education is debatable, there is a definite need for greater study on the subject, but if we give an example from the literature.

It can be mentioned the characteristics of STEM education in terms of different views. If we consider the characteristics of STEM education from the point of view of the student (Gallant, 2010), a student who has received a STEM education will be an individual who can solve problems, think logically, have technology literacy, and can combine their culture with their learning. If it is considered from the point of view of the classroom, Akgündüz (2018) state that how STEM education should be given in the classroom and how its boundaries should be drawn have not yet been defined very well. However, Gallant (2010) states that STEM classroom, which provides students with a variety of learning styles as well as those with disabilities, centers students in the classroom, has computers with STEM software, and has easily modular furniture from grades 6 to 12. Yıldırım (2018) asked teachers how a STEM class should be. It was argued that teachers should have the necessary materials to be able to do the application, the classes should be suitable for group work, and there should be computers and smart boards (Yıldırım, 2018). Also, when examined in terms of STEM school, Gallant (2010) explained that a STEM school is a school that promotes a culture that fosters STEM literacy, has educational materials, and encourages inquiry, creativity, shaping, and performance-based practices.

2.1.2 Importance of STEM education in science education

Akgündüz (2018) mention that STEM components, science and mathematics, combined with engineering and technology, can be produced and this production paves the way for the economy. Among the studies conducted with STEM, the researchers also mentioned the importance of STEM. In this way, it can be tried to find an answer to the question of why STEM education and so there are different reasons and opinions about its importance. For example, Brown et al. (2011) interrogated the importance of STEM in their study and emphasized that participants in this study thought that STEM is important because it serves as an interdisciplinary bridge and provides a conceptual building block for students. Moreover, according to White (2014), this educational effort aimed to provide all students with critical thinking abilities that would enable them to solve problems creatively and, as a result, make them more employable. In addition to all, Akgündüz (2018) mentioned in their book about the importance of STEM education, and stated that with STEM education, it is tried to create learning environments that will enable students to solve real-life problems covering more than one discipline and establish interdisciplinary relationships.

2.1.3 Studies about STEM Education

International and national studies related to STEM will be reviewed in this section. Studies have been conducted for recognizing STEM education such as investigating the views of teachers. For instance, in the study conducted by Yıldırım (2018), it was revealed the views of the teachers who included STEM applications in their lessons with all its dimensions. Six teachers working in different provinces participated in the study. Data are collected by using qualitative research method and used "STEM Teacher Interview Form (SÖGF)" consisting of 7 questions. It was emphasized that teachers do not feel competent about content knowledge and that a good STEM teacher should have knowledge of the field, pedagogy, engineering, and their integration. In addition, it was emphasized that strategies and methods such as project-based learning, research-based learning and problem-based learning should be used during STEM applications. Other example is that in the study conducted by Özcan and Koştur (2018), the aim is to collect teacher's views about STEM education. A qualitative research method was used, and data were collected by asking an open-ended question that is "What is STEM?". 85 science teachers that have an experience of only 1 or 2 years working in public or private schools participated in the study. As a result, it was seen that the newly graduated teachers gave comprehensive, detailed, and correct answers to the question asked. Moreover, there are some studies by conducting with faculty members. For example, Breiner et al., (2012), in their studies, by asking some questions to faculty members investigated the definition of STEM education and how STEM education affects our lives. Although 72 % of the faculty members participating in the study were interested in STEM, the results showed that there was no common STEM conceptualism. Concepts often depend on academic discipline or how STEM affects their daily lives. Also, some studies were conducted to investigate the STEM perceptions of students. For instance, Çakmak (2019) conducted a study that the aim of this research is to examine the STEM perceptions of middle school students determined according to certain criteria (gender, school type, grade level, parents' education level, parents' occupations, family income level, whether there is an engineer in the family). As a result of the data analysis, the students limited technology to only electronic goods. Also, they mentioned the importance of mathematics, creativity, problem solving, brainstorming and experimentation for engineers. In contrast, some investigations were reported (Brown, 2012 and Hasanah, 2020). Brown (2012) analyzed the eight journals focused on STEM discipline in his study. The results of the analysis summarize how often different research in STEM education is done, the results of the research on this topic, the participants, and the universities affiliated with the research. In addition, Hasanah (2020) investigated key definitions of STEM education and underlined the different definitions of STEM education in literature. Literature search was done through Educational Resources Information Center, Scopus, Web of Science and Google Scholar. Four key definitions that are “Instruction”, “Curriculum”, “Major”, “Career” and three scopes that include those major definitions based on literature reviews are found and described.

2.2 ENGINEERING

One of the reforms made in education to increase the workforce of developing and developing countries is to include engineering in education. With engineering education, STEM has entered our lives and it is aimed to develop students’ 21st century skills. In this part, the definition of engineering, the importance of it and some studies related to it are mentioned.

When examining the literature on the definition of engineering, there are different opinions. While some define it as a profession, some consider it as a person. Others have defined engineering based on the work engineering has done. Additionally, Chou and Chen (2017) described an engineer as a person who works in the field of engineering. However, Çakmak et al. (2019) defined engineering as one of the components of STEM and a profession that has the ability and potential to change the quality of life of people positively or negatively. Also, Brophy et al. (2008) mentioned about definition of engineering in their article that when many developers of engineering learning materials are asked about the definition of engineering and what they do, they mention that engineers invent innovations and processes, improve existing ones, and come up with new things to meet people’s needs by using mathematics and science.

Over time engineering became important in science education. With the development of Industry 4.0, it can be observed that the machines are used in production instead of the labor force, so that situation leads to change in employment and reveals some jobs such as wearable technology designer, data security specialist or 3D printer engineering (Akgündüz,2018). In order to prepare children for the future with this, they should use education models suitable for 21st century skills (Akgündüz,2018). The skills we call 21st century skills are communication, cooperation, critical thinking and creativity in general terms (Akgündüz, 2018). Anymore, a person who is an engineer by getting a bachelor's degree at the university must have certain characteristics such as practical and analytical thinking, problem solving, and the ability to use imagination and creativity. According to Akgül et al. (2013), the aim of engineering education can be summarized as enabling the student to produce practical and analytical solutions for the problems they may encounter, improving their design skills and solving design problems in the most efficient way by using existing materials and systems.

In this context, it can be seen that there is a similarity between the changes needed in education at a young age and the aims of engineering education. That is, the skills to be acquired with 21st century skills are similar to the skills included in the purpose of engineering education. Therefore, it is necessary to integrate engineering education into science education at an earlier age in a way that connects it with other disciplines. In this way, it will be possible to train young people who are ready for the changing world, changing technologies and different business areas, with advanced 21st century skills, who will make innovations by reconciling their engineering skills with the concepts they know in science.

2.2.1 Studies about engineering

With the inclusion of the concept of engineering in our curriculum, it has been a matter of curiosity about what teachers and students know about it. There are some studies on this subject. Some of them were conducted with students. For example, Çakmak et al. (2019) conducted a study to examine how middle school students perceive the concept of engineering and their profession. A total of 627 middle school students participated in the study. The mixed method was used in the study. As a result of the study, it was found that the students did not have enough knowledge about the engineering field, and they perceived engineering as a male profession. Also, Chou and Chen (2017) conducted a study by using the Chinese-version of the Draw-an-Engineer Test (CDET), and the aim of the study was to collect views of students about conceptions of engineers. A mixed methods research methodology was used and with content analysis, and data were analyzed. 750 Taiwanese students participated in the study. it was seen that the children were influenced by the family and the mass media, and the presence of gender, certain types of engineers and basic concepts were seen in the drawing (Chou & Chen, 2017). Some of researchers were investigated views of teacher about engineering. For instance, Hammack and Ivey (2017) investigated science teachers' perceptions about engineering and engineering design. The results of the first stage were used to end the interview held in the second stage. 545 K-5 public school teachers participated in this study. Data were analyzed with mixed methods research. Data were collected by applying online questionnaire that include Likert, selected response, and open-ended items. It was found that the participants did not have much knowledge about the subject. Participants also stated that they have little experience in engineering. In addition, teachers could not distinguish between science examples and engineering activities (Hammack & Ivey, 2017). Also, Hacıoğlu et al. (2016) aimed to collect the opinions of teachers who participated in engineering design-based education examples in their study. 65 teachers participated in the study. Qualitative research method was used. Data were collected with the opinion form prepared on engineering design-based education. As a result of the study, teachers expressed their positive and negative opinions at the end of the study. Teachers stated that they support engineering design-oriented science education. They also stated that it can be applied in their classes when the necessary conditions are met (Hacıoğlu et al., 2016). Moreover, Sarı and Yazıcı (2019) conducted a study about science and engineering applications. The aim of the study was to investigate the views of teachers about science and engineering applications. 20 science teachers participated in the study. Qualitative research method was used. Data were collected with a semi-structured form. It has been analyzed with data content analysis. As a result of the study, teachers generally have a positive opinion about the contribution of engineering to science education. They also think that engineering will contribute to science education. However, in the implementation part, teachers see themselves as inadequate. When asked about their work on this subject, they said that they would prepare presentations about the life of scientists and engineers, and preparing product files, designing problem-based projects, and solving simple design problems (Sarı & Yazıcı, 2019).

2.3 NATURE OF ENGINEERING (NOE)

Before understanding the nature of engineering, it is necessary to understand what the nature of science. Antink-Meyer and Brown (2019) suggested that NOS helps students grasp the relationships between science and their daily lives by translating the questions and situations that scientists investigate and explain. Also, according to Antink-Meyer and Brown (2019), NOS promotes person 's ways of understanding the natural world, the role of data and evidence, decision-making about that world. On the other hand, McComas et al. (1998) defined that NOS is a sophisticated field that mixes social studies of science including the history, sociology, and philosophy of science. In order for nature of engineering to be understood well, nature of science should be well understood because it has been claimed in the literature that there is a connection between these two (Deniz et al., 2020). Deniz et al.(2020) explained the relationship between NOE and NOS. They said that in the field of science education, NOS is such a well-researched area. Therefore, the emerging NOE research field and its conceptualization can also be shaped in the light of the historical process of NOS science in science education (Deniz et al., 2020). Also, Antink-Meyer and Brown (2019) mentioned the relationship between them and they said that the NOS and NOE benefit from the philosophy, sociology, and history of engineering and technology literatures. In this point, why should NOE be known? Why is it associated with NOS?. These situations should be considered. In reference to Karataş et al. (2010), NOE should be knowable because of an understanding of engineering, science education and NOS.

The changes made in education with the changing world, the inclusion of engineering in our curriculum (MoNE, 2018) revealed the importance of understanding engineering. To understand engineering is to understand its nature. Therefore, especially those who will give engineering education should have NOE knowledge. There are important studies in the literature on NOE. One of them was carried out by Deniz et al (2020). According to Deniz et al. (2020), it is necessary to prepare a common list of engineering nature aspects for everyone about the concept of the nature of engineering as part of the engineering design process designed by the NGSS. Therefore, they created some NOE aspects based on the literature. These common NOE aspects are demarcation, engineering design process, empirical basis, tentativeness, creativity, subjectivity, social aspect of engineering, and social and cultural embeddedness. In the following sections, NOE aspects are explained.

Demarcation

Demarcation NOE aspect refers to the meaning of engineering what do engineers do? According to Deniz et al. (2020), while engineering produces solutions to problems and deals with the design, the engineer uses his own knowledge to do this.

Engineering Design Process

It is the process by which engineering design takes place. According to Deniz et al. (2020), there are three main components of the engineering design process including define, design and optimize. Define involves defining and classifying an existing problem according to its criteria and limits (Deniz et al., 2020). Design step involves listing all available solutions and choosing the best among them. (Deniz et al., 2020). The Optimization part is about design testing.

Empirical Basis

According to Deniz et al. (2020), engineers make the best use of their designs and compare their data with other evidence-based results

Tentativeness

Engineers can make changes to their designs for the better or revise their designs to meet different criteria (Deniz et al., 2020)

Creativity

Creativity and imagination play an important role in the engineering design process and play a role at any stage of the engineering design process. (Deniz et al., 2020). Also, Hartman (2016) stated that in addition to logical thinking, engineers use their creativity in problem definition, design, application, and communication processes.

Subjectivity

An engineering design problem does not have a unique solution, and one problem has lots of solutions, but some solutions better meet limits and criteria. (Deniz et al., 2020)

Social Aspect of Engineering

Although there are individual differences, engineers have common understanding and values, which leads to an increase in the quality of the solutions in engineering design. This only happens with social discussion. (Deniz et al., 2020)

Social and Cultural Embeddedness

This NOE aspect describes the relationship between society and engineering. Since engineering is a human activity, it is affected by sociocultural factors such as social composition, religion, worldview, political and economic, and thus affects society (Deniz et al., 2020).

2.3.1 Studies about nature of engineering

There were some studies about the NOE concept. The studies about the NOE aspect showed to understand this aspect from different perspectives. One of them was conducted by Hartman (2016). According to Hartman (2016), although interest in engineering has increased, the characteristics and unique features of engineering are not clearly defined, so the aim of the study was to explain the suitable aspects of NOE at K-12 level. A total of 610 experts (science teachers, engineering teachers, science education faculty, and engineering education faculty) in K-12 engineering education are the participants of this study in a three-round Delphi study classically, and a qualitative coding method was used to analyze data (Hartman,2016). As a result of the study, NOE was defined as the replicable process that uses mathematics, science, criteria and constraints to design solutions to meet human needs and requests. Also, thanks to the Delphi process, 8 nature of engineering aspects have been determined. Divergent, Creative, and Iterative received the highest marks for these aspects. It is thought that these results will help the development of engineering at the K12 level.

(Hartman, 2016).

Other study was conducted by Deniz et al. (2020) to determine effects of elementary teachers' perceptions of the nature of engineering (NOE) after solving an engineering design problem. 30 elementary teachers that are from different schools participated in this study. A NOE questionnaire with open-ended questions (VNOE-A) that included seven questions and individual interviews were used to collect data. Investigators defined nature of aspects that are demarcation, engineering design process, empirical basis, tentativeness, creativity, subjectivity, social aspects of engineering, and social and cultural embeddedness. The findings of the current study were in favor of using more explicit and reflective teaching techniques to impart NOE knowledge during engineering design activities (Deniz et al., 2020).

Another study about NOE conducted by Kaya (2020). In his study, it is mentioned that STEM education has the aim of introducing and developing NOE. Investigators tried to investigate relevant NOE aspect among students to develop multifaceted views of NOE among students. However, it is found that there is no reliable instrument to evaluate the conception of NOE, so the study conducted by Kaya has two aims, and these are to describe NOE aspects on the basis of NGSS and the National Research Councils' Framework for K-12 Science Education ,and to develop a new open-ended Nature of Engineering Instrument - Version B (VNOE-B) that is empirically sound, trustworthy, and valid, partly based on a Views of the Nature of Engineering (VNOE) survey meant to gauge students' NOE perspectives. Also, developed a new instrument (VNOE-B) addressed to answer how engineering experts and non-experts respond to the VNOE-B, and what the similarities and differences are, if any, between engineering experts' and non-experts' NOE views? (Kaya, 2020). The participants are two groups that are beginners and experts, and while beginners are pre-service teachers, experts are engineering educators and professional engineers that work in high institutions (Kaya, 2020). VNOE-B questionnaire was used to collect data and semi-structured interviews were used to answer the research questions of the study (Kaya, 2020). Also, a qualitative MaxQDA application was used to analyze data (Kaya, 2020). With the results of the study, the effects of the VNOE-B questionnaire on educational practices are discussed, and it is thought that it will guide the teachers and students interested in science and engineering to improve their opinions.

Also, Karataş et al. (2011) examined 6th-grade students' views about NOE to both present engineering processes and works. Also, it is provided a foundation for the development of which activities, or curriculum material. Phenomenographic framework was used to analyze data. The participants were 6th-grade students and the result of the study showed that the students' ideas about engineers and engineering were flimsy, unstable, and prone to shift during the interview (Karataş et al., 2011).

Moreover, Karataş et al. (2016) conducted another study about NOE, and the aim of the study was to collect the first-grade engineering students views about NOE. The study (Karataş et al., 2016) investigates the process of engineering, the beliefs of students about good engineer and product that results from good engineering process, and the views of students about difference and similarities of NOS and NOE. 114 students out of 838 students participated in this study (Karataş et al., 2016). A questionnaire that includes 12 items of open-ended questions was developed. While data are analyzed, distinct categories and clusters are designed qualitatively. As a result of the study, students defined engineering studies as a problem solving, a form of applied science, a system involving design or creativity. It has also been found that engineering studies have limitations, include a better environment and lifestyle for people, and technological progress, have teamwork, require skill and creativity, and are based on scientific knowledge and experience. (Karataş et al., 2016).

2.4 Summary of the Chapter

In general, there are many studies on STEM education and engineering in the literature. The opinions of the teachers and students were examined and reports on these subjects were published. Regarding the nature of engineering, there are few aspect-based studies that are related to NOS. In addition, there were limitations in some aspects of the studies. For example, Deniz et al. (2020) stated in their study that there were limitations in the aspects of social nature of engineering and empirical.

CHAPTER 3

METHODOLOGY

The aim of this part is to introduce the design of the study, the participants of the study, data collection, data analysis, validity, reliability and trustworthiness of the study and finally the limitations of the study.

3.1 Design of The Study

In this study, the aim is to understand and reveal the views of the middle school science teachers about the nature of engineering. Therefore, the qualitative research method was appropriate and utilized in this study because according to Fraenkel et al., qualitative technique focuses on comprehending events and situations from the perspective of the participants (2015). There are some approaches to qualitative studies. One of these approaches is case study (Fraenkel et al.,2015). In current study, qualitative research method was used by applying case study approaches. According to Yin (2011), three are four types of case study. One of them is single holistic case study. The present study was a single organization and data were collected from a group of science teachers. Therefore, in current study, single holistic case study was used. In this study, to find out the views of teachers about the nature of engineering, open-ended question were taken from the relevant literature (Deniz et al., 2020; Kaya, 2020).

3.2 Participants of the Study

It is needed for participants that are knowledgeable about the content instead of choosing participants that are irrelevant to the subjects because the aim of the study is to collect the views of teachers about content, so in this study, the participants were selected according to the purposive sampling method. It is appropriate for the study because according to Fraenkel et al. (2015), researchers do not just investigate everybody who is accessible; instead, they use their judgment to pick a sample that they feel will offer the data they want based on past knowledge. Moreover, there are lots of types of purposive sampling methods. Two of these types of purposive sampling are typical sample and snowball sample. According to Fraenkel et al. (2015) a typical sample means selecting participants thought to be related to the subject. Also, again in terms of Fraenkel et al. (2015), snowball sample means selecting participants recommended by others. Therefore, in this study, two of these types were used to select teachers that are science teachers in middle school in the Central Anatolia Region.

Nine science teachers participated in this study, and it was interviewed with them. Also, their answers were recorded. Moreover, some demographic information is gathered from these nine teachers. These demographic information includes the age, the organization where the teachers work, work experience, gender, alma mater, their taken STEM education, STEM knowledge and interest, knowledge of engineering and how much engineering is included in their courses. Eight of the participants are female and the other is male. The age range of the participants is between 26 and 42. While six of the participants teach science in a private school, three of them teach in a public school. The professional experience of teachers is between 2 and 18 years. Some of the participants had previously received STEM education, while others did not. All participants did not have a master's or doctorate. In addition, the participants' STEM knowledge, interests, and scores on STEM applications in the course differ. Data about the demographic are shown in the Table 3.1 shortly.

Table 3.1: Demographic Information about teachers

Participant	Age	Gender	School Type	Professional Experience	Graduated Faculty	Master or Doctora Degree	Received STEM Education	Interested in STEM Education	Knowledge About STEM Education	Knowledge About Engineering	How Much Engineering and Its Applications in Science Lessons	How Confident In Making Engineering Applications in Classroom
P1	28	Female	Public	5	Science Education	-	Yes	3	4	3	2	4
P2	35	Male	Private	15	Science Education	-	Yes	3	3	3	4	2
P3	26	Female	Private	2	Science Education	-	Yes	3	3	3	3	3
P4	31	Female	Public	7	Science Education	-	No	3	2	2	2	2
P5	30	Female	Private	6	Science Education	-	No	3	3	2	2	3
P6	28	Female	Public	3	Science Education	-	No	3	3	2	2	2
P7	29	Female	Private	5	Science Education	-	No	4	2	2	3	3
P8	26	Female	Private	4	Science Education	-	Yes	3	3	3	4	3
P9	42	Female	Private	18	Science Education	-	No	1	1	1	2	1

3.3 Data Collection

In the qualitative research method, three main techniques are utilized to gather and analyze the data (Fraenkel et al., 2015). Interviewing techniques is one of them. In this study, the data were collected by conducting interviews with teachers. Since the aim of this study is to reveal and collect the opinions in people's minds, the interview technique was preferred in this study because the aim of the interviewing is to bring into open their thoughts (Fraenkel et al., 2015). Furthermore, there are some types of interviews. Semi structured open-ended interview is one of them and operated in this study. Nine teachers participated in this study. They were asked 7 open-ended questions, and their answers were recorded. The questions are determined previously, and all the same questions are asked to teachers in the same alignment.

3.3.1 Description of The Instruments

Since the introduction of the concept of engineering into the education system, many studies have begun to be made about the nature of engineering. In one of these studies was conducted by Deniz et al. in 2020. On the part of Deniz et al. (2020), it was developed NOE aspects called Views of Nature of engineering Questionnaire type A

(VNOE-A) including *demarcation, engineering design process (EDP) empirical basis, tentativeness, creativity, subjectivity, the social aspect of engineering and social and cultural embeddedness* aspects. However, in the study conducted by Deniz et al. (2020), it has some limitations. According to Deniz et al. (2020), their design for the NOE questionnaire was not efficient in collecting data about empirical and social NOE aspects. Also, another study about NOE was carried out by Kaya (2020). In his study, it is critical to explain the proper NOE features in K-12 STEM education to improve students' engineering literacy. Also, a new instrument for some NOE aspects was developed whose name is Views of Nature of engineering Questionnaire type B (VNOE-B). According to Kaya (2020), the following aspects are included in the study, but are not limited to set conditions that engineering solutions are multiple and subject to revision for further development, data-centric and evidence-based, creative, and imaginative, designed in a systematic way, collaborative, constrained by criteria, failure-laden, influenced by and influence society, culture, and politics, and distinct from science and other disciplines in their goals.

From this point of view, in the present study, the questions are adapted to Turkish from mentioned studies and used as an instrument, and it was made a pilot study with two middle school science teachers and one engineer. The aim of the pilot study is to understand whether the questions are understandable, and the answers are consistent with the questions, or not. As a result of the pilot study, some questions were removed from the instrument because they were not understood by teachers, or the answers were irrelevant. Also, one question changed when adopting into Turkish, but the meaning and its NOE aspect were the same. Some changes are given in the Table 3.2.

Table 3.2: The questions that are removed from the instrument

Questions	NOE Aspect
Engineers need to balance competing criteria and constraints when solving engineering problems. Using an example, explain some of the various factors that engineers often need to consider as they design.	Criteria and constraints
In your opinion, what is the role of failure in the engineering design process? Explain your answer with a concrete example.	Failure-laden
How do engineers know that their design solutions meet the required criteria and constraints as they engage in engineering design? Explain your answer with an example.	Empirical testing

Other changes are given in the Table 3.3.

Table 3.3: The question that was changed

The question from the VNOE-A	NOE Aspect	The question in this study	NOE Aspect
There is a variety of soda cancrushers commercially available in the market. Can there be a single best design for a soda can crusher? If you believe that there is a single best design for a soda can crusher, please explain why. If you believe that there is not a single best design for a soda can crusher, please explain why.	Subjectivity	Computers are widely used nowadays. Computer mice have been produced in order to use the cursor provided by the operating system more easily while using the computer. There are a variety of computer mice commercially available on the market. Could there be a "best" and "one type" design for these various computer mice developed by engineers?, and why?	Subjectivity

As a consequence of that, one question whose NOE aspect about social and collaboration is taken from the Views of Nature of engineering Questionnaire (VNOE-B) scale developed by Kaya (2020). Other questions on the scale except for one question that is related to social aspects of NOE are quoted from the Views of Nature of engineering Questionnaire (VNOE-A) scale developed by Deniz et al. (2020). In the present study, it was conducted a list of NOE aspects taken from these studies, and these common NOE aspects for this study are demarcation, engineering design process, tentativeness, creativity and imagination, social and cultural embeddedness, subjectivity, social and collaborative. The questionnaire used in this study, and their NOE aspects are in the Table 3.4.

Table 3.4: The questions and their NOE Aspects

Questionnaire	NOE Aspects
1a. What, in your view, is engineering? 1b. What makes engineering different from other disciplines (e.g., science, philosophy, religion)?	Demarcation
2. What is an engineering design process? Explain your answer with examples.	Engineering design process
3. After engineers have developed an engineering design does the design ever change? • If you believe that engineering designs do not change, explain why. Defend your answer with examples. • If you believe that engineering designs do change, explain why.	Tentativeness
4. Do engineers use their creativity and imagination during the engineering design process? • If yes, then at which stages of the engineering design process do you believe that engineers use their creativity and imagination: identifying the problem; developing the design conceptually; constructing the design, testing the design; refining the design? Please explain why engineers use creativity and imagination. Provide examples if appropriate • If you believe that engineers do not use creativity and imagination, please explain why. Provide examples if appropriate.	Creativity and imagination
5. Some claim that engineering is infused with social and cultural values. That is, engineering reflects the social and political values, philosophical assumptions, and intellectual norms of the culture in which it is practiced. Others claim that engineering is universal. That is, engineering transcends national and cultural boundaries and is not affected by social, political, and philosophical values, and intellectual norms of the culture in which it is practiced. • If you believe that engineering reflects social and cultural values, explain why and how. Defend your answer with examples. • If you believe that engineering is universal, explain why and how. Defend your answer with examples.	Social and cultural embeddedness
6. Computer is used a lot nowadays. Computer mice have been produced in order to use the cursor provided by the operating system more easily while using the computer. There are a variety of computer mice commercially available on the market. Could there be a "best" and "one type" design for these various computer mice developed by engineers? Yes or not, and why?	Subjectivity
7a. How do engineers work? Alone or in a group (team)? 7b. Describe how working with teammates might contribute to the outcomes of engineering projects. 7c. Discuss the advantages and disadvantages of working with teammates. Support your answer with examples.	Social and collaborative

3.4 Data Analysis

Fraenkel et al. (2015) stated that, in qualitative research, content analysis can be used for collecting and analyzing data. Also, they defined content analysis that it is a method that enables researchers to examine human communication in an indirect manner in order to analyze human behavior. In their communications, a person or a group frequently reveals their conscious or unconscious views, attitudes, values, and ideas. coding methods will be utilized to analyze the data that are obtained from the informants (Fraenkel et al., 2015). In this study, to analyzing the data, content analysis was used and data were coded. The questions were categorized with short key words while the data were categorized in terms of types that are code-designed. That means the answers are coded based on keywords. These categories were given in the Table 3.5.

Table 3.5: Coding about teachers' views about NOE

Categories	**Subcategories**
Definition of engineering	Design
	Product development
	Field
	Job
	Creating something
	Development
	Produce solutions
	Invention
	Marketing

Continued on next page

Table 3.5 – *continued from previous page*

Categories	**Subcategories**
Different from other discipline	Using other disciplines and produce product
	Application
	Production based
	Using other disciplines and quiding the development
	Product creation
	Related but not science, an effort to produce something
	Problem solving, making life easier
	Innovation
	Combining digital with social life
	Requiring imagination and creativity
Definition of EDP	Process
	Finding a solution to the problem
	Working on obtaining product
	Stage
	A fictional process
	Drawing
	Calculating cost
Changes engineering design	Yes

Continued on next page

Table 3.5 – *continued from previous page*

Categories	**Subcategories**
	Not exact accuracy
	Based on creativity
	Needs
	İmaginations
	Making life easier
	Thinking we can do better
	Change of mind
Why changes engineering design	Disapproval
	Purpose of use
	Based on technological development
	Innovation
	Success
	Change of use
	Economic conditions
	Environmental conditions
Using creativity and imagination	use creativity and imagination
	Finding solution to problem
	Ergonomic
	For production to begin
	Based on design
	Different product
Why using creativity and imagination	Good product
	Progressing
	Contributing to humanity
	Successful
	Be attractive
	Easy to sell

Continued on next page

Table 3.5 – *continued from previous page*

Categories	**Subcategories**
Which stage using creativity and imagination	Each stage The stage of fixing the design The stage of creation of design The stage of conceptualization The stage of development of design The stage of finding problems
Universal or nonuniversal	Both of them Universal Not universal Not universal, but should be universal
Why universal or nonuniversal	Information used Creativity Job A branch of production and creativity Needs based Problem based Be influenced by others
One best and type design	There cannot be one best and only type of design There can be only one type of design but not the best There can be only one type of design
Why one best and type design	Purpose of usage Different anatomy People' preference Specific purpose of usage Serve many purposes Need for use
Working type	Both of them Group

Continued on next page

Table 3.5 – *continued from previous page*

Categories	Subcategories
Contributions of working teammates	More ideas
	More creativity
	Different knowledge of engineers
	More ideas
	Error-free work with collaboration
	Different ideas
	Save time
Advantages of working teammates	More ideas
	More creativity
	Different judgment
	Different ideas
	Developing their creativity and ideas
	Quality work without errors, solving problems faster
	Speed of working together
	Taking a second look
	Error-free
	Quick job completion
	Making job easier
Disadvantages of working teammates	Not listen to others
	Communication problems
	Financial problems
	Disagreement
	Disrespect for an opinion

3.5 Validity, Reliability and Trustworthiness

Trustworthiness and reliability are indispensable for a study. Researchers draw based on the data they gather; on the other hand, reliability means the constancy of the ratings (Fraenkel et al., 2015). Also, in this part, trustworthiness was explained for qualitative research.

3.5.1 Consistency

The question of whether the study gives the same results if it is done a second time is about reliability (Baltacı, 2019). In this study, an inter-rater method was used to check reliability. To ensure consistency, in this study, while the 25% of the answers of the teachers were coded, the answers of one of the nine teachers were independently coded by the supervisor of the thesis and compared with the coding of the researcher.The coding made by different people was compared and the calculation was made using the Miles Huberman formula calculation. As a result of the calculation, it was seen that 80% of the answers were compatible.

3.5.2 Trustworthiness

The better the credibility is provided, the more the trustworthiness has been overcome. In this study, many discussions were regularly held with the supervisor about the study. It is something that increases consistency with the presence of two supervisors and the expert review method.Also, to handle with this, member checking method was used. Merriam (1998) stated that member checking is used in studies as a strategies by obtaining data then back to the people to understand whether the result is sensible. During the coding process, the interviewed teachers were asked to confirm whether what they meant or understood was correct. Moreover, considering the demographic information of the researchers, it was seen that triangulation was made. Merriam (1998) mentioned that triangulation means using multiple investigators, data or methods and is used as a strategies. In this study, care was taken to collect data from people with different characteristics. It has been tried to ensure the participation of teachers with different age experiences and school characteristics. Opinions were not collected by specifying a single age, school type or characteristic.

3.6 Assumptions

In this study, there are some assumptions. It was assumed that all participants participated in the study on a voluntary basis. It was thought that all participants answered the questions honestly and willingly. Appropriate conditions were provided for the questions to be answered.

3.7 Limitations

Some parts may not give the situations we want in the study. The limitations of this study are given below.

1. The time is limited to develop new instruments and to reach more participants. This study actually can be done in a long time by using mixed methods that are qualitative and quantitative.
2. The instrument taken from Deniz et al.'s (2020) had some limitations, and the NOE questionnaire was not efficient in collecting data about empirical and social NOE aspects. In the present study, to overcome this situation, the NOE aspect about social also is taken from another study conducted by Kaya (2020). However, the question about the empirical NOE aspect taken from Kaya (2020) removed from the current study. Therefore, in the present study the empirical NOE aspect is limited.

CHAPTER 4

RESULTS

The views of the teachers about nature of engineering were examined on the basis of aspects. In this part, the answers received from the teachers are explained with examples.

4.1 Demarcation

In order to reveal the demarcation aspect of the nature of engineering, 9 science teachers were asked about the definition of engineering. Teachers have a mostly different view about it. Some of them have defined the same, but even the same concepts can differ for different reasons or purposes. P1 (participant 1) explained the definition of engineering as designing and development. Also, P9 (participant 9) defined the definition of engineering as a design. The differences between them are that P1 also defined designing with using science. Moreover, P9 also identified engineering as an invention and marketing, and said that:

> *"it is designing something, inventing, and then marketing."*

Another participant P2 (participant 2) described engineering as a field that facilitates human life. Also, P2 and P8 (participant 8) had the same definitions, and they described engineering as a job. The following are explanations of P2 and P8,

> *"Engineering is a job that makes the work more practical and makes human life easier by using science." (P2)*

> *"Engineering is a job that should definitely be in our lives so that a society can*

progress and shape the future." (P8)

In contrast to them, P3 (participant 3) identified engineering as creating something by using different terms from others and explained that engineering is building new things that make daily life easier, and P5 defined it as production of a solution, and remarked that engineering is to produce solutions suitable for the needs of the person. Apart from these, P4 (participant 4) and P6 (participant 6) determined the same views about the definition of engineering, and defined it as a product development, but they had a different definition of product development. Although P4 identified engineering as product development by using science, P6 defined it as a product development that facilitates human life and uses technology. In addition to that, P7 identified engineering as a product development process. With process word, P7 differed from the P6 and P4, and remarked that;

> *"Engineering is a process that the necessary steps are at work, planning, organization, after production, if there is an error, its rectification, measures, revision, etc."*

Also, P7 defined it as a production of a solution, and so, with this view, P7 agreed with P5. Furthermore, to show the demarcation aspect again, nine science teachers were asked about the features that differ engineering from other disciplines. The results are mostly different, only two participants have the same explanation, and others have different explanations about the question. P1 differed engineering from the other disciplines by mentioning product creation. P1 thought that engineering creates production by using scientific knowledge that means other disciplines. In addition to that, P4 varied engineering from other disciplines by referring to:

> *"Engineering uses other disciplines and guides its development, and mathematics, science, and physics are the basis of this. Engineering directs its own development by using them. Engineering is not a science on its own; it must use other sciences. For example, the engineer has to know physics."*

Also, P5 had an opinion about the questions like partially P1, and she explained the alteration about engineering from other disciplines as product creation. In contrast to these answers, P2 had a different view. P2 varied engineering from other disciplines by mentioning application. P2 said that;

> *"It is the field of science that allows us to find out how the world works, but the part that makes our life easier, which is transferred to us in daily life in this process, is the professional unit that thinks about it. While science is only looking at how this job works, I look at how I use it, how I use it, engineering is separated from there, frankly, as an application."*

While the other participants passed their remarks like that, P3 differed engineering from other disciplines by explaining terms of production base. P3 thought that:

> *"This is the feature that distinguishes it from other branches because it is a continuous production situation in engineering, but this does not mean anything, it does not mean a branch independent from mathematics and physics, but it is different from others because it is based on production."*

Also, when P6 was asked the difference between engineering and other disciplines, P6 mentioned that engineering is related to science, but it is not a science, and explained engineering as an effort to produce something. Apart from these, P7 and P8 also put forward different views. Although P7 mentioned that engineering is a problem solver and makes our lives easier while explaining the difference of engineering from other branches of science, P8 explained the difference of engineering from other branches of science as follows; innovative thinking power and combining numbers with a little more social life. In addition, P9 believed that engineering requires creativity and imagination.

4.2 Engineering design process

In order to understand the views about the engineering design process (EDP), 9 science teachers were asked what the EDP is, and in order to get detailed information, it was asked to explain with an example. The answers are mostly the same. 4 participants out of 9 were defined EDP as a process, and gave partially different detailed information about what they understand from the 'process' term. Although P1 defined process terms as the process it goes through to create a product with your newly existing scientific knowledge, P3 explained that it is based on identifying the problem, then forming the hypothesis, collecting data and finally producing a solution. In addition to all, P5 and P7 identify the EDP to explain the word of process. P5 said that:

> *"When we look at it in general terms, it is defined as a process. The plans were made, the draft and the prototype were prepared according to the planning, the prototypical was returned to the beginning according to the plus or the minuses, and a product was created as a result of all these."*

In fact, a process has been described by P5. The participant supported what he said with a telephone example:

> *"We have a phone, but that it has a negative side, and that we fix it in our daily life and create a new phone."*

In addition to that, P7 talked about a process and explained the process as determining the problem, dreaming or designing the product that will solve the problem, planning the necessary material and environment conditions, procedures, and starting production in the process. On the other hand, P8 expressed an opinion very close to the opinion of the other four participants and defined it as a fictional process in which science branches such as physics are used to design the product, mathematical calculations are made, and then a product is produced using the engineer's steps. In contrast to these views, P2 mentioned different opinions and he thought engineering was regarded as finding solutions to problems. The participant also explained this problem-solving event with the example of a car. According to the P2,

> *"A car is made from legos, the car he makes is like this, there are so many on this Instagram, he builds a car to pass through the gap between two tables, then he extends that gap a little bit, the car falls and makes a car again, this is what I say every time, by trying the things we use in science and is designing this tool by solving these problems. That is, he designs the vehicle in a way that will find a solution to every kind of problem, that is, to the problem that may be encountered. This process is the design process that I have observed."*

Another participant with a different view is P4. She defined the EDP as working on obtaining products that are obtained by finding a problem or determining something we want to do, then determining how to plan, what we need, the materials, and research on the subject. On the other hand, P6 stated that:

> *Mathematics knowledge about science is used and carried out engineering studies in the final stage of design.*

Finally, P9 voiced her opinion with all reserves and described EDP as making a drawing of the product or calculating the cost.

4.3 Tentativeness

To understand the tentativeness aspect of the nature of engineering, teachers were asked whether engineering designs made by engineers would change over time. Looking at all the answers, nine out of all nine teachers answered " yes". They all think that engineering design will change over time. When the reason for this was asked it was seen that the views of the teachers differed. Although some have mentioned the same reason, the answers differ in the majority. First of all, when asking teachers why the engineering design process can change over time, the P1 argued that there is no real accuracy, there is creativity and that a drawing can be changed or something more ergonomically designed can also be changed. In contrast to that reason, five out of nine science teachers identified the reason for the change in engineering design as needs. P2 stated that the engineering design could change and this change in line with the needs, and he said:

> *"The design of cars became streamlined. There was a little less fuel. Here the weight of the materials used has changed, so no matter what we call it, the design is changing because it got involved with electronics. A request to create a place has been entered, so the design of the vehicles has changed, the mobile phone is the best example of them. When we say big phone, we turn to small, the design of everything is changing, frankly."*

Also, P2 mentioned imagination, making life easier, and thinking we can do better as reasons, but this participant mostly thinks that the reason is the needs of people. In addition, P3 argued that engineering designs could change and explained the reason for this with the change of in our needs in daily life and supported her idea with an example. P3 talked about the changes in the structures of the buildings, the changes in the materials used, the effect of this situation on the areas of use in daily life, and thus our needs in daily life have changed with the developing technology. According to this participant, this situation also affects the engineering process. In addition to that, P6 stated that it changed according to the needs, too. Also, P6 supported her idea by mentioning that there used to be no seat belts but they are now used, the warning lights were not lit before, but they are now placed in cars as an extra, and there is no phone, now they are in cars. P5, on the other hand, talked about the need while explaining the reasons, and also mentioned that it depends on technological developments. Moreover, P5 argued that needs have changed. In fact, with this part, P5 was of the same mind with P2, P3 and P6 directly. Here, she supported what she said with the example of the dryer and said that:

> *"In the past years there was a washing machine but no dryer. Over time, as people's work gains speed, people can disrupt their daily work. To facilitate this, they may need new machinery to accelerate. This is the dryer, for example, I can say this."*

Another participant mentioned needs when asked why the engineering design change is P7. She also emphasized that not only needs but also innovations can cause changes in engineering designs. In addition to that, P8 defended the view that the reasons for the change of engineering designs are success, change in usage, innovation. When mentioning innovation, P8 had the same view with as P7. P8 explained the idea of change in usage and success like this.

> *"Let's say he built a road or built a bridge, this bridge failed as planned over time, or the usage changed, for example, I threw 100 vehicles while 1000 vehicles started to pass at a daily capacity and engineering must be innovative. That's why the engineering design may change."*

In contrast to them, P4 expressed her opinion with a different thought than the other participants. P4 explained that engineering designs could change with the change of mind, thought to be unsuitable or changing the purpose of use. In addition, he explained the change in the way of use with an example and said:

> *"For example, let's say whatever he designs a bridge, for example, a bridge that will connect two continents, something that is requested from him can be intended only for cars at work, then he must add a road that his bikes can pass through, so we may have to design the calculations again."*

Finally, P9 has a very different view than the other participants on this issue. The participant stated that the design might change according to environmental and economic conditions. The participant supported her idea with examples and said:

> *"An environmentally friendly material has been found, for example, it can be switched to plastic, or an abundant resource has been obtained at work, it may be more economical, it may be something with the same volume but more spectacular, maybe anything."*

4.4 Creativity

Three different questions were asked to science teachers to understand the teachers' views on the creativity aspect.

The first question is on engineers' use of creativity and imagination. All science teachers who participated in this study answered that engineers would use their creativity and imagination. Furthermore, when asked why engineers use their creativity and imagination,the answers given about the reasons are very different from each other. For example, P1, P5 and P7 partially agreed on one issue. They thought that creativity and imagination came into play as they were looking for a solution to a problem. P1 said:

> *"While designing something, an engineer may look for a solution to an existing problem or come up with an idea to transform an existing thing into a more useful and advanced form. During this situation, he uses his originality, imagination, and creativity."*

P5 also explained

"They come up with a product, this product comes out depending on the problem, so they need to find solutions to solve this problem. Although they need technical knowledge to produce it, it is important to have imagination and creativity in order to come up with something different."

In addition, P7 said that

"Using our old knowledge or existing applications in solving some problems might not lead us to an effective solution. Creativity needs to be used here so that we can come up with a solution that doesn't exist yet."

All the remaining participants gave different reasons why they used creativity and imagination. While P2 expressed that engineer use their creativity and imagination in order for a product they will produce to be ergonomic, in short, P3 attributed the engineers' use of creativity and imagination to the fact that the engineering field is based on designs. She supported what she said with an example:

"If imagination and creativity were not effective, there would be only one pattern and every engineer would bring it to life. For example, the purpose of the use of bridges is the same all over the world, but their designs are different from each other. This is because not every bridge is designed by the same engineer."

In contrast, P4 stated that engineers use their imagination and creativity in the design and problem determination step, so different products are formed. Moreover, P6 and P8 also had different views about this question. Although P6 said that:

"I will say to do a good job, but to get the full reward"

P8 mentioned that the engineers use their creativity and imagination to progress and to contribute to humanity, and said that:

"In order for engineering to progress and develop, something must be done other than the same, that is, if the past products are repeated, the society cannot progress."

Finally, P9 had a different view from them. She expressed that engineers use creativity and imagination because they use creativity and imagination to succeed, stand out from others, and sell easy products.

Also, the teachers were asked the question that is "at which stage of the engineering design process does he use his creativity and imagination, that is, in which step he can use it in determining the problem, in the conceptual development of the design, in the creation of the design, in testing the design, in the correction of the design, etc.?" Some of the answers here are diversified. Although P1, P5, P6, and P7 suggested that engineers use their creativity and imagination in every stage, P3,P4 and P9 claimed that engineers use their creativity and imagination in the stage of creation of the design. Also, P3 added to it that engineers also use them in the stage of conceptualization and development of design while P4 added their view to the stage of conceptualization, and stage of finding problems. In addition to P3, P8 had a view about it, and she thought that engineers use them in the development stage of design.

4.5 Social and Cultural Embeddedness

This NOE aspect identifies the connection between society and engineering. To understand this aspect, teachers were asked the following question *"Some claim that engineering is infused with social and cultural values. That is, engineering reflects the social and political values, philosophical assumptions, and intellectual norms of the culture in which it is practiced. Others claim that engineering is universal. That is, engineering transcends national and cultural boundaries and is not affected by social, political, and philosophical values, and intellectual norms of the culture in which it is practiced. If you believe that engineering reflects social and cultural values, explain why and how. Defend your answer with examples. If you believe that engineering is universal, explain why and how. Defend your answer with examples."* There are different views about this aspect. Only one participant thought that engineering is universal. Four teachers out of nine explained not only is engineering universal but also engineering is infused with social and cultural values. Also, other Four teachers out of nine mentioned that engineering is infused with social and cultural values. Considering the reason for this situation, although there are different opinions, some teachers have reached a consensus. P1 stated that engineering is both influenced by social and cultural values and is universal. When asked reason, P1 explained that the information used in engineering would not change, so it was universal. However, she stated that creativity is used in products generated by using this information, and creativity is subjective. Moreover, P1 supported what she said with an example:

> *"The region I work in when designing a dishwasher, let's say if I live in Africa, in the region I am in, that dishwasher has no meaning. You know, after all, a dishwasher is something that is used with water. There is a water shortage in Africa. But the parts you use or the physics or other knowledge you will use, you use them, it is universal, but you design it in a way that you can adapt to the region."*

P4 completely agreed with P1. P4 mentioned that engineering uses a common concept and she said:

> *"They use a common thing when creating a concept, they use that science, according to you, there is no such thing as according to me, but what we call imagination is still ours because we are influenced by our environment since we were born, I think engineers are affected."*

In addition to these, P6 expressed creativity in terms of its reason, but argued that engineering as an idea is influenced by the social environment. P6 also mentioned that creativity would emerge according to the environment we live in. P6 did not mention it's universal. In addition, P3 states that engineering as an idea is influenced by the social environment. When the participant was asked why it was affected, P3 replied:

> *"Since engineering is a branch of creativity and production, I think it is definitely influenced by the environment in which a person grows up. It totally depends on one's production and imagination. one's imagination is also affected by the social environment and cultural values. If I give an example, for example, we can go from a vehicle design or a building design. In the design of buildings in Turkey, for example, the dome can reflect this on some buildings, for example, but a person who grew up in a place where there is no mosque or dome structures will reflect this."*

In contrast to them, P2 stated that it is universal. He also stated that engineering is a profession that facilitates life, facilitates humanity, and facilitates people's lives. Therefore, it should not be reflected differently in different cultures. P2 just mentioned differently and said:

> *"In the marketing part, I think that cultural norms are affected, but I think it should not be."*

The P5 is one of the participants with a different opinion. This participant thought like P3 and P6 that engineering is infused with social and cultural values. However, the reasons put forward by the participant were very different from the others.She stated that engineering might change depending on the needs and problems in the country we live in. Also, she claimed that people first see the problems in their immediate surroundings, and since they will solve the problems in their vicinity, they will therefore stay connected to their social environment. P7 and P8 also stated that engineering, like P1 and P4, is both universal and influenced by social and cultural norms. However, when asked why it was affected, it was seen that the answers given by the participants were different from all other participants. While P7 said that:

> *"The development of engineering is definitely affected by the cultural environment, but I think that is affected by the cultural environment does not harm its universality. In other words, the cultural environment is both affected by the cultural environment and is universal. For example, let's say, for example, the pyramids of Egypt or the engineering that emerged in that region in Egypt were affected by the culture of the region, but the development or engineering products obtained from there were also used in different parts of the world."*

P8 discussed that it could be differentiated as an engineering type. She mentioned food engineering is affected by the social environment and said:

> *"While cheese is a very important concept in society, a food engineer can decide whether the society wants cheese consumption or more organic or not, while working on cheese."*

However, P8 also stated that civil engineering would not be affected by the people around while constructing a building. Finally, P9 had a completely different view and stated that engineering should be universal, but it is not like that in our country because as a society, people are definitely under the influence of each other because they affect each other so much.

4.6 Subjectivity

To understand the subjectivity aspect when looking at teachers' views on the nature of engineering, teachers were asked whether there might be one best and one type of design among various computer mouse, or not. Seven science teachers out of nine claimed that there could not be one best and only type of design. One science teacher out of nine supported the idea that there can be only one type of design but not the best. P1 stated that there could not be one best and only type of design. When asked teachers why you think so, P1 mentioned that it is used for different purposes. P1 also supported her idea by saying that there are people who use it for the game. Moreover, P1 mentioned that it could be designed to appeal to the preference of each person individually. In addition to that, P1 claimed to be suitable for anatomy, and said:

> *"Not everyone's hands are the same size and not the same mold, so everyone can choose a mouse that is comfortable for them, so we can say that there are many varieties."*

Furthermore, P2 is completely similar to P1 in his thinking. He thought that there could not be one best and only type of design because of different purposes of usage, not suitable for anatomy for everyone, based on people's preference. Also, he supported that everyone has a different hand size and the purpose of use is different, for example, it is used for games, speed is required, a wired design is required to move more easily. Also he mentioned the people's different preference and said that:

> *"My hand is partially large, and I don't like small designs, frankly."*

Moreover, P9 claimed as the same with P1 and P2 partially that there cannot be one best and only type of design because the people had a different purpose of usage and different anatomic, and said that:

> *"For example, I use my right hand, but it is not better for left-handed people,*

or I don't know, gamers need a more specialized mouse."

In addition to these, P5 and P8 stated that there cannot be one best and only type of design. Also, P5 and P8 have the same view as P1 and P2 in that human are anatomically different. P5 said that:

> *"People are very different from each other, there are left-handed people, there are right-handed people or there are people with disabilities. You know, it is not very possible to appeal to everyone in the society, but I think it is important to have as much diversity as possible, so I believe that it cannot be uniform."*

Like P5, P8 argued that there would not be a single type and best design because everyone's anatomical structure is different, and she said that:

> *"Small child will also hold it, a large person or an old man or maybe someone with a physical problem in his hand will also hold that mouse, so the same design cannot be used as not every person's grip will be the same."*

Also, P7 partially thought like P1 and P2. The reason was that since everyone's preference are different, she stated that there would not be a single type and best design. Also, P4 claimed that there could not be one best and only type of design. The reason for this is partially similar to P1, P2 and P7. She mentioned there cannot be one best and only type of design because people have a different preference. Also, she mentioned as a reason that there is no one best and only type of design because of need for use, and she said:

> *"It varies according to the ergonomics of everyone's usage needs. For example, some people do not like the clicking sound, some like it, and some work in a very quiet place. If he works in a place where there should be no sound, for example, he can use a mouse that does not make a clicking sound."*

In contrast, P3 had completely different views about this question. She thought that there could be only one type of design but not the best because she stated that the mouse has a specific purpose of usage, but that it does not mean the best for people. Accordingly, she stated:

"Because the purpose of the mouse is clear, that is, we use it to move the cursor or to select and click something, so I think it may be uniform, but that doesn't mean that it will be the most efficient tool for all people."

Finally, another participant who gave a very different answer from the others is P6. She claimed only one type of design, but she did not mention the best of design. Also, she argued about the reason why the engineering design can be only one type that only what we call comfort has changed, other than that, it is designed in the most comfortable way suitable for human hands, it is different, but not much different. Also, she explained that thickness could vary depending on preference, but there is only one type of design.

4.7 Social and Collaborative

With social and collaborative aspect, three different questions were asked to reveal the views of the teachers. One of them is how engineers work. Alone or in a group (team)? The answers do not differ much. Although P1, P2, P3, P5, P6 and P9 stated that the engineers work in a group, P4, P7 and P8 claimed that engineers work not only alone but also in a group.

In addition, in this aspect, everyone was asked how working with their teammates contributes to the outcome of an engineering project. P1, P2, P3, P5, and P6 have roughly the same opinion on this question. Everyone except P1 talked about the emergence of different ideas, more ideas as the contribution of working with teammates to the outcome of an engineering project. P2 said that:

"More ideas are always good. I think it will be fine. Agreeing, of course, is important here in the team."

Also, P3 stated that there would be more opportunities to develop ideas by brainstorming. In addition, P5 argued that working with the group as the main idea would reveal different ideas and said that:

"Everyone has a unique imagination, so the solution proposals they offer to a problem in daily life may be different from each other, so the solution proposal

offered by one engineer may be different from another engineer. This is how brainstorming occurs."

Moreover, P6 said that:

> *"It makes a positive contribution in every way. More thoughts, more ideas can be revealed. As a result, a single idea is not always correct, many ideas on a subject pave the way for it, they can move on to different thoughts. I can say that collaborative work is important."*

P1, on the other hand, mentioned the emergence of more ideas as a contribution, like the others. In addition, he also mentions that each engineer has different knowledge in a different field, and therefore, a better product can be produced when working together. Another participant who thinks that engineers in different fields have different knowledge and expertise is P4, and said that:

> *"I think teamwork is more important for everything because everyone makes up for each other's deficiencies. After all, I think that a single engineer cannot work on a technical issue because it usually needs to be combined from many fields."*

In addition to these, the thinking of the P7 is not very different from the others. The participant claimed that cooperation is good, that different ideas cannot arise, and that events can be handled from different perspectives. In contrast to them, P8 and P9 have the same idea about it, but different ideas from others. Both of them are thought that error-free work with collaboration is a contribution to the engineering design project. Although P8 said that:

> *"Strength always comes from unity. Progress is more complete, less margin of error."*

P9 said that:

> *"If there is a deficiency, it will be noticed more easily, you will see more than one eye."*

Also, P9 mentioned that the projects would progress faster.

Furthermore, under this aspect again, everyone was asked what the advantages and disadvantages of working with teammates are?.

When asked about the advantages of working with teammates, the answers are much different. P1, P5 and P6 had the same views about the advantages of working in a team. They thought that getting more ideas if you work in a team. However, P1 also expressed other advantages that working with a team leads to more creativity and it provides the opportunity to criticize and comment from different places on the product. Also, P5 added to her thought and mentioned that this would be an advantage as the product could be reached faster when working together. In contrast to them, P2 and P4 had different ideas from all others. P2 suggested that working with a team caused different ideas, and said:

> *"Different ideas always open new doors."*

While P4 suggested that it enables people to solve problems faster, and people can generate quality work without errors. In contrast to them, P3 and P7 also had different views about these issues from others. While P3 thought that working with group mates would improve creativity and thinking, P7 argued that a second eye would always contribute. In addition, P9 seemed to have the same view as P7 when asked about the advantages of group work. She argued like P7 that taking a second look was an advantage of working in a team. Also, she mentioned that it leads to an easier job. Finally, P8 seemed to have a different view when asked about the advantages of group work. She mentioned the error-free, quick job completion, and said that:

> *"When you work with your teammates, you will complete the work in a shorter time because you divide the work, and at the same time, your margin of error is lower."*

When asked about the disadvantages of working with teammates, the answers are not much different. P1, P3, P4, P5, P7, P8, and P9 mentioned the disagreement of people as a general disadvantage, but they expressed their thoughts in different ways. Although P1 mentioned that there might be a conflict of opinion and one of them may work more and the other may work less this will cause problems, P3 claimed that the mentality of engineers who did not fit in personality would not fit together. Also, P4 argued that non-compliance with one of the participatory working styles might cause conflicts and added that there might be cultural differences as well. In addition, the participant mentioned that there may be people who want to be at the forefront, and that the other person may not like our work. In addition, P7 believed in short that disagreement was a disadvantage, and she said:

> *"There may be people who do not believe the way you believe, then such a struggle for the soul arises. I think this may be a disadvantage. It may cause unnecessary waste of time in the reconciliation process."*

Moreover, P8 and P9 suggested that disagreement was one of the main disadvantages. While P8 talked about conflicts as disagreements, P9 mentioned disagreement again that if you do not have a good colleague, it will be a hindrance. Furthermore, P5 agreed that the disagreement among engineers was the disadvantage, and said that:

> *"There may be differences of opinion and people may not reach an agreement on the solution point."*

Also, she mentioned that there could be financial and communication problems among the team, so it was also a disadvantage for her. In contrast, P2 argued that if people do not listen to others, it will be a disadvantage. Finally, P6 had a different view from others. She thought that disrespect for an opinion was a disadvantage in the working group.

4.8 Summary of The Results

Teachers have different perspectives on the nature of engineering. Questions about demarcation and the engineering design process have varying responses, in particular. The teachers often responded in a similar manner to the inquiries on the aspects of tentativeness, creativity and imagination. They believed that engineering design is adaptable and that engineering requires imagination and creativity. However, the explanations of its results offered again vary. Very few persons who commented on the social and cultural embeddedness aspect considered that society has an impact on engineering. The majority of people believed that engineering did not have a singular solution under subjectivity aspect. The majority of teachers stated that engineers work with group when discussing the social component of engineering. However, they have different opinion about advantages and disadvantages about working with teammates.

CHAPTER 5

CONCLUSION AND DISCUSSION

In this chapter, the results of the current study are explained with literature.

5.1 Discussion

The results of the study are mentioned in this part. The aim of the study is to investigate the science teachers' nature of engineering views. Therefore, pre-prepared questions were asked to science teachers by using semi-structured interviews. Then, data were analyzed qualitatively by using the coding method.

A definition of engineering and the differences engineering from other disciplines was asked to teachers to collect teacher opinions about the demarcation aspect. Even though some of them talk about the same opinion, the answers given in general are different from each other. Generally, when asking the definition of engineering, science teachers defined it as design, development, field, job, creating something, product development, producing solutions, and product development process. From the literature, the demarcation aspect of engineering is defined as designs that find a solution to a specific problem. (Deniz et al., 2020). In the current study looking at the answers, it was seen that two science teachers defined it as finding a solution to the problem, partially close to the literature. Looking at the demographic information, it was seen that these two participants chose 3 and 4 in the given range from 1 to 4 when asked about their STEM interests. In addition, these people are people who apply STEM education in their classes. It can be concluded that this is the reason why the answers are close to the definition in the literature. Moreover, the other two participants talked about design and made a definition partially close to the definition in the literature. One of the participants who gave this answer is the person who gave the highest answer when asked about their interest and knowledge in STEM. The reason why the participant gave a close answer may be that he knows about this subject. Interestingly, the STEM knowledge and interest of another participant who gave this answer is in the 1-2 level range. However, the participant is the person with the oldest age and the highest school experience among the other participants. It may be possible to attribute the participant's answer to her experience.

Furthermore, when the answers to the question of the difference between engineering and other disciplines are examined, different results have been obtained again. Generally, teachers differed engineering from other disciplines by mentioning production based, application, using other disciplines and guiding the development, product creation, relationship with science and affording to produce something, problem-solving, making life easier, innovation, combining digital with social life, and requiring imagination and creativity. In literature, it was mentioned about the differences between engineering and other disciplines that engineering used scientific knowledge to solve real-life problems (Deniz et al., 2020). In the current study results, two participants defined partially what are the differences engineering from other disciplines like the definition from literature. Both thought that engineering use scientific knowledge. People who respond like that are expected under normal conditions to have STEM knowledge. One of the participants who gave this answer is a participant who is interested in STEM and has STEM knowledge. However, another participant did not receive STEM training and had little interest in STEM.

Surprisingly, looking at the definitions of engineering in the literature and its difference from other disciplines, two of the people who gave the closest answer in the current study are those who are not related to STEM. In a previous study (e.g., Kaya, 2020), the results were as expected. For example, in a study conducted by Kaya (2020), the participants consisted of two groups. One of the groups is an expert group and consists of engineering educators and professional engineers. The novice group consists of pre-service and/or in-service elementary teachers. When they were asked about the definition of engineering and its difference from other disciplines, the participants in the novice group made explanations that included partial or misconceptions. Also, in another study (Antink-Meyer & Arias, 2022), it was not studied on an aspect basis like the current study, but by applying professional development (PD), teachers' opinions about NOE were taken before and after PD. Teachers' definition of the relationship between science, mathematics and engineering was examined in the study. The definitions of teachers with limited NOE knowledge were that engineering is the same as science and math. (Antink-Meyer & Arias, 2022)

The definition of the engineering design process (EDP) as an aspect was asked to the teachers. The answers were generally different. Teachers generally defined EDP as a process, finding a solution to the problem, working on obtaining product, stage, frictional process, drawing and calculating cost. From the literature, EDP defined that it had three components that are define, design, and optimize (Deniz et al., 2020). Only one teacher gave the closest definition to this definition in the literature. That is, an answer is partially like the description of NOE aspect. However, this participation mentioned the definition and the design part and not optimization. There are similar results in the literature. Deniz et al. (2020) stated in their study that teachers had less EDP knowledge before the intervention. Also, similarly, Hammock and Ivey (2017) worked with elementary teachers in their studies. They took the opinions of the teachers about engineering and engineering design. When teachers were asked what they thought about the engineering design process, they generally stated that they had little or no knowledge about it (Hammock & Ivey, 2017).

Teachers were asked if engineering designs would change under the tentativeness aspect. In the literature, it is mentioned that engineering designs can be changed, to achieve the desired goal or to meet different criteria (Deniz et al, 2020). In this study, the answers were the same and yes as literature. However, the reasons of it were different among teachers. Generally, teachers thought the change because of needs, imaginations, making life easier, thinking we can do better, change of mind, disapproval, the purpose of use, based on technological development, innovations, success, change of use, economic condition, environmental conditions, not exact accuracy, based on creativity. Looking at the answers of the teachers in this study, it was seen that most closely one teacher said that engineering designs could be changed to succeed. While considering the demographic information of this teacher, it was seen that she received STEM education. This may be possible reason for giving an answer that might be close to the literature.

Looking at the literature, the creativity aspect is defined as an important part of the engineering design process (Deniz et al., 2020). All participants have the same ideas about using imaginations. Similarly, this question was also asked in a study conducted by Kaya (2020) and the participants emphasized that creativity plays an important role in engineering design process.

The literature stated about social and cultural embeddedness that engineering is human endeavor. It is mentioned that social and cultural influences affect EDP, and engineering affects society (Deniz et al., 2020). As a result of the current study, only three teachers out of the nine explained an answer as a description of NOE aspect directly. Similarly, Kaya (2020) mentioned in his study that the novice group failed to define this question. Looking at the demographic information of teachers that answered this question, it was seen that the STEM knowledge and interest of these three teachers was number 3 in the range given from 1 to 4. There may be a reason why they can make explanations according to the literature.

The subjectivity aspect can be defined as that engineering design problems do not have unique solutions (Deniz et al., 2020). In the current study, seven teachers out of nine teachers responded as in the literature. It could not be established a relationship between the answer given by looking at the demographic information because it was seen that the demographic information of the teachers differed. On the other hand, similarity has been seen in the literature. For example, the aspect-free question was asked to first-year engineering students in the study conducted by Karataş et al., (2016). In this study, first-year engineering students were asked whether the resulting product would be similar if engineers working in two different companies were given the same task. Considering that engineering students do not have a very good knowledge of engineering, 84% of the answers of the participants are that the products may be different, just like in the current study.

The definition of the social aspect of engineering in the literature said that engineering would take place in a social way, not alone. It was also mentioned that although personalities are different, differences are shared in the social environment, and in this case, it makes a positive contribution to engineering design solutions (Deniz et al., 2020). Looking at the answers of the teachers who participated in the study in general, almost all of them gave answers for working in groups and made a completely correct definition like literature. In terms of the advantages and disadvantages, there are fewer participants who explain the idea that sharing different thoughts and values contributes to engineering design solutions, as in the literature. In the demographic information of one of the people who made this statement, it was seen that this participant had received STEM education before. Also, looking at the demographic information of two other people who gave this answer, it was seen that their STEM knowledge got 3 points from 1 to 4 points. Perhaps this might have contributed to the answer given.

5.2 Conclusion

This current study was conducted to investigate the science teachers' nature of engineering views. The results showed that even though some answers are the same, teachers generally have different opinions. Judging by their demographic information, the reasons for this are that their experience, their interest in STEM and their knowledge about STEM are different, so according to demographic information, by looking at the definition of aspects in the literature, by examining other studies in the literature, some inferences were made about the answers of the teachers.

5.3 Implications and Recommendations for Future Studies

In the light of the results of this study, it can be said that teachers' views on the nature of engineering are complex. It has been observed that teachers cannot fully focus on the nature of engineering issue because as a result of the study, there are teachers with many different ideas. For STEM education to be transferred to students in a real sense, the nature of engineering should be understood very well. Its applications in the classroom and classroom planning should be understood very well by teachers. Therefore, it is necessary to increase the knowledge level of teachers on this subject. In this context, workshops may be organized, or in-service training seminars might be given to inform teachers about the nature of engineering and how to include engineering in science education.

Some suggestions can be made also for pre-service teachers. In fact, what is liked or not liked or interested begins to take shape in the university environment before entering the business environment. In order to make teachers like STEM education and to invest in the future, courses that provide STEM education at universities can be added. Even workshops on this subject can be organized for them.

Considering the missing parts of this study, some suggestions will be made for future studies. Studies based on these aspects are limited. In order to support the literature, by using these aspects, studies on the nature of engineering should be done. Also, these studies might be done with teachers at different levels and be taken their opinions. Moreover, Deniz et al., (2020) stated that there are some limitations in their work about empirical aspect. Then, this aspect was used in the study conducted by Kaya (2020), but he worked with pre-service teachers, engineering educators and professional engineers in his study. In current study, the questionnaires did not include aspect of empirical. In future studies, it may include this aspect, and these future studies may conduct with teachers that are middle school or different levels.

REFERENCES

Akgündüz, D. (2018). Okul öncesinden üniversiteye kuram ve uygulamada STEM eğitimi. Ankara: Anı Yayıncılık.

Akgündüz, D., Aydeniz, M., Çakmakçı, G., Çavaş, B., Çorlu, M. S., Öner, T., & Özdemir, S. (2015). STEM eğitimi Türkiye raporu. İstanbul: Scala Basım.

Akgül, A., Muhammed, U. Ç. A. R., Öztürk, M., & Ziya, E. K. Ş. İ. (2013). Mühendislik eğitiminin iyileştirilmesine yönelik öneriler, geleceğin mühendisleri ve işgücü analizi. Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 17(1), 14-18.

Antink-Meyer, A., & Brown, R. A. (2019). Nature of engineering knowledge. Science Education, 28(3), 539-559.

Antink-Meyer, A., & Arias, A. M. (2022). Teachers' incorporation of epistemic practices in K-8 Engineering and Their Views About the Nature of Engineering Knowledge. Science Education, 31(2), 357-382.

Baltacı, A. (2019). Nitel araştırma süreci: Nitel bir araştırma nasıl yapılır?. Ahi Evran Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 5(2), 368-388.

Breiner, J. M., Harkness, S. S., Johnson, C. C., & Koehler, C. M. (2012). What is STEM? A discussion about conceptions of STEM in education and partnerships. School Science and Mathematics, 112(1), 3-11.

Brophy, S., Klein, S., Portsmore, M., & Rogers, C. (2008). Advancing engineering education in P-12 classrooms. Journal of Engineering Education, 97(3), 369-387.

Brown, J. (2012). The current status of STEM education research. Journal of STEM Education: Innovations and Research, 13(5).

Brown, R., Brown, J., Reardon, K., & Merrill, C. (2011). Understanding STEM: Current perceptions. Technology and Engineering Teacher, 70(6), 5.

Bybee, R. W. (2010). What is STEM education?. Science, 329(5995), 996-996.

Cansoy, R. (2018). Uluslararası çerçevelere göre 21. yüzyıl becerileri ve eğitim sisteminde kazandırılması. İnsan ve Toplum Bilimleri Araştırmaları Dergisi, 7(4), 3112-3134.

Chou, P., & Chen, W. (2017). Elementary school students' conceptions of engineers: A drawing analysis study in Taiwan. International Journal of Engineering Education, 33(1), 476-488.

Çakmak, B. (2019). Ortaokul öğrencilerinin fen, teknoloji, mühendislik ve matematik (STEM) algıları.

Çakmak, b., Bilen, k., & Taner, m. s. (2019). Ortaokul öğrencilerinin mühendis ve mühendislik algilari. Anadolu Öğretmen Dergisi, 3(1), 32-43.

Deniz, H., Kaya, E., Yesilyurt, E., & Trabia, M. (2020). The influence of an engineering design experience on elementary teachers' nature of engineering views. International Journal of Technology and Design Education, 30(4), 635-656.

Eastwell, P. (2002). The nature of science. Science Education Review, 1(2), 43-48.

Fraenkel J.R., Norman E.W., & Hyun H.H. (2015). How to design and evaluate research in education. New York: McGraw-Hill Education.

Gallant, D. J. (2010). Science, technology, engineering, and mathematics (STEM) education. Ohio State University.

Gilbert, S. W. (1991). Model building and a definition of science. Journal of Research in Science Teaching, 28(1), 73–79. doi: 10.1002/tea.3660280107

Gonzalez, H. B., & Kuenzi, J. J. (2012, August). Science, technology, engineering, and mathematics (STEM) education: A primer. Washington, DC: Congressional Research Service, Library of Congress.

Günay, D. (2017). Teknoloji Nedir? felsefi bir yaklaşım . Yükseköğretim ve Bilim Dergisi , (1) , 163-166 . Retrieved from https://dergipark.org.tr/en/pub/highereduscі/issue/61492/918222

Hacıoğlu, Y., Yamak, H., & Kavak, N. (2016). Mühendislik tasarım temelli fen eğitimi ile ilgili öğretmen görüşleri. Bartın University Journal of Faculty of Education, 5(3), 807-830.

Hammack, R., & Ivey, T. (2017). Elementary teachers' perceptions of engineering and engineering design. Journal of Research in STEM Education, 3(1/2), 48-68.

Hartman, B. D. (2016). Aspects of the nature of engineering for K-12 science education: A Delphi study.

Hasanah, U. (2020). Key definitions of STEM education: Literature review. Interdisciplinary Journal of Environmental and Science Education, 16(3), e2217. https://doi.org/ 10.29333/ijese/8336

Karatas, F. O., Micklos, A., & Bodner, G. M. (2011). Sixth-grade students' views of the nature of engineering and images of engineers. Journal of Science Education and Technology, 20(2), 123-135.

Karatas, F. O., Goktas, Y., & Bodner, G. M. (2010, November). An argument about nature of engineering (NOE) and placing the NOE into engineering education curriculum. In Proceedings of Turkey's Vision 2023 Conference Series: International Engineering Education Conference, Antalya, Turkey (pp. 4-6).

Karataş, F. Ö., Bodner, G. M., & Unal, S. (2016). First-year engineering students' views of the nature of engineering: implications for engineering programmes. European Journal of Engineering Education, 41(1), 1-22.

Kaya, E. (2020). Toward developing a valid and reliable assessment of learners' nature of engineering views (Doctoral dissertation, University of Nevada, Las Vegas).

Kola, A. J. (2013, January 23). Importance of science education to national development and problems militating against its development. Retrieved from http://pubs.sciepub.com/education/1/7/2/.

McComas, W. F., Clough, M. P., & Almazroa, H. (1998). The role and character of the nature of science in science education. In The nature of science in science education (pp. 3-39). Springer, Dordrecht.

MEB (2018), (Milli Eğitim Bakanlığı Talim ve Terbiye Kurulu Başkanlığı). Fen bilimleri dersi öğretim programı (ilkokul ve ortaokul 3, 4, 5, 6, 7 ve 8. sınıflar). Ankara: MEB Yayınevi.

Merriam, S. B. (1998). Qualitative Research and Case Study Applications in Education. Revised and expanded from" case study research in education.". Jossey-Bass Publishers, 350 Sansome St, San Francisco, CA 94104.

National Research Council. (1996). National science education standards. National Academies Press.

Özcan, H. & Koştur, H. İ. (2018). Fen bilimleri dersi öğretmenlerinin STEM eğitimine yönelik görüşleri . Sakarya University Journal of Education , Vol: 8 Issue: 4 (Supplement Issue) , 364-373 . DOI:10.19126/suje.466841

Sanders, M. (2009). STEM, STEM Education, STEMmania. The Technology Teacher, 68(4), 20-26.

Sarı, U. & Yazıcı, Y. Y. (2019). Fen bilgisi öğretmenlerinin fen ve mühendislik uygulamaları hakkında görüşleri . International Journal of Social Sciences and Education Research , 5 (2) , 157-167.

Toluk, Z. (2003). Üçüncü uluslararası matematik ve fen araştırması (TIMSS): Matematik Nedir. İlköğretim-Online, 2(1), 36-41.

U.S. Department of Education. (2007). Report of the academic competitiveness council. Washington, D.C.

Yıldırım, B. (2018). STEM uygulamalarına yönelik öğretmen görüşlerinin incelenmesi. Eğitim Kuram ve Uygulama Araştırmaları Dergisi, 4(1), 42-53.

Yin, R. K. (2011). Applications of case study research. Thousand Oaks: Sage.

White, D. W. (2014). What is STEM education and why is it important. Florida Association of Teacher Educators Journal, 1(14), 1-9.

Appendix A

ETHICS COMMITTEE PERMISSION FORM

Figure A.1: Ethics Committee Permission Form

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY

DUMLUPINAR BULVARI 06800
ÇANKAYA ANKARA/TURKEY
T: +90 312 210 22 91
F: +90 312 210 79 59
ueam@metu.edu.tr
www.ueam.metu.edu.tr

Sayı: 28620816 /

14 MART 2022

Konu : Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi : İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Jale ÇAKIROĞLU

Danışmanlığını yürüttüğünüz Nurseli İRDEM AĞRIMAN'ın "Fen Bilimleri öğretmenlerinin mühendisliğin doğasına yönelik görüşleri" başlıklı araştırmanız İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve **0158-ODTUİAEK-2022** protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız.

Appendix B

QUESTIONS OF THE QUESTIONNAIRE

Figure B.1: Questionnaire - page 1

MÜHENDİSLİĞİN DOĞASINA YÖNELİK GÖRÜŞLER

Açıklama

Aşağıdaki sorular öğretmenlerin mühendisliğin doğasına yönelik görüşlerini almak için oluşturulmuştur. Verilen cevaplar yüksek lisans tezinde kullanılacaktır.

- Lütfen aşağıda bulunan her soruyu cevaplayınız.
- Soruları cevaplamak için altlarındaki boşlukları kullanabilirsiniz.
- Her sorunun "doğru" ya da "yanlış" bir cevabı yoktur. Sorularla ilgili sizlerin görüşleri dikkate alınacaktır.

1. Cinsiyetiniz: ☐ Kadın ☐ Erkek
2. Yaşınız: ___________
3. Öğretmenlik yaptığınız okulun adı: ________________________
4. Öğretmenlik yaptığınız okul: Devlet ☐ Özel ☐
5. Mesleki tecrübeniz (yıl): ________
6. Mezun olduğunuz fakültenin adı ve bölümü: __________________/__________________
7. Eğer Yüksek Lisans / Doktora yaptıysanız derece aldığınız alanın adı:

   ☐ Yüksek Lisans: ___________________________

   ☐ Doktora: _________________________________

8. Daha önce STEM eğitimi aldınız mı? ☐ Evet ☐ Hayır

Cevabınız **Evet** ise lütfen aldığınız eğitimi belirtin: _______________

9. STEM öğretimine ne kadar ilgi duyuyorsunuz?
   ☐ Oldukça çok ☐ Biraz ☐ Az ☐ Hiç
10. STEM öğretimi hakkında ne kadar bilgilisiniz?
    ☐ Oldukça çok ☐ Biraz ☐ Az ☐ Hiç
11. Mühendislik hakkında ne kadar bilgilisiniz?
    ☐ Oldukça çok ☐ Biraz ☐ Az ☐ Hiç
12. Mühendislik ve uygulamalarına fen derslerinizde ne kadar yer veriyorsunuz?
    ☐ Oldukça çok ☐ Biraz ☐ Az ☐ Hiç
13. Sınıfınızda mühendislik uygulamaları yapma konusunda kendinize ne kadar güveniyorsunuz?
    ☐ Oldukça çok ☐ Biraz ☐ Az ☐ Hiç

Figure B.2: Questionnaire - page 2

1. a. Size göre mühendislik nedir?

   b. Mühendisliği diğer bilim dallarından (fen, felsefe, matematik gibi) farklı yapan nelerdir?

2. Mühendislik tasarım süreci nedir? Lütfen bir örnekle açıklayınız.
3. Mühendislerin yaptığı mühendislik tasarımları zaman içinde değişebilir mi?
   a. Eğer cevabınız **evet** ise nedenini bir örnekle destekleyerek açıklayınız.
   b. Eğer cevabınız **hayır** ise nedenini bir örnekle destekleyerek açıklayınız.
4. Mühendisler mühendislik tasarım sürecinde yaratıcılıklarını ve hayal güçlerini kullanır mı?
   a. Eğer cevabınız **evet** ise nedenini bir örnekle açıklayınız. Mühendislik tasarım sürecinin hangi evresinde (problemi belirleme, tasarımın kavramsal olarak geliştirilmesi; tasarımın oluşturulması, tasarımın test edilmesi; tasarımın düzeltilmesi gibi) yaratıcılık ve hayal gücünü kullandığını düşünüyorsunuz: Cevabınızı bir örnekle açıklayınız.
   b. Eğer cevabınız **hayır** ise nedenini bir örnekle açıklayınız.
5. Bazı iddialara göre mühendislik sosyal ve kültürel değerlerden etkilenir. Yani mühendislik uygulandığı kültürün sosyal ve politik değerlerini, felsefi varsayımlarını ve kültürün entellektüel normlarını yansıtır. Diğer iddialar ise mühendisliğin evrensel olduğudur. Yani mühendislik ulusal ve kültürel sınırları aşar ve sosyal, politik, filozofik değerlerden ve entellektüel normlardan etkilenmez. Siz hangisine inanıyorsunuz?
   a. Eğer mühendisliğin sosyal ve kültürel değerleri yansıttığını düşünüyorsanız, örnek vererek açıklayınız.
   b. Eğer mühendisliğin evrensel olduğunu düşünüyorsanız örnek vererek açıklayınız.
6. Bilgisayar günümüzde çok kullanılmaktadır. Bilgisayarı kullanırken işletim sisteminin sağlamış olduğu imleci daha rahat kullanabilmek adına bilgisayar fareleri üretilmiştir. Piyasada ticari olarak çeşitli bilgisayar fareleri bulunmaktadır. Mühendislerin geliştirdiği bu çeşitli bilgisayar fareleri için **"en iyi"** ve **"tek bir tip"** tasarım olabilir mi?

   ❑ Evet, çünkü____

   ❑ Hayır, çünkü____

7. a. Mühendisler nasıl çalışırlar? Yalnız olarak mı yoksa grup (takım) halinde mi?

   b. Takım arkadaşları ile çalışmanın bir mühendislik projesinin sonucuna nasıl bir katkı sağlar, lütfen açıklayınız.

   c. Takım arkadaşları ile çalışmanın avantajları ve dezavantajları nelerdir? Cevabınızı örneklerle destekleyiniz.

Appendix C

INSTRUMENT PERMISSION FORM 1

Figure C.1: Instrument Permission Form 1

WEBER STATE UNIVERSITY
College of Science

To Whom It May Concern,

Any researcher who would like to use the Views of Nature of Engineering (VNOE) questionnaire can do so with the following citation.

Deniz, H., Kaya, E., **Yesilyurt, E.,** & Trabia, M. (2020). The influence of an authentic engineering design experience on elementary teachers' nature of engineering views. *International Journal of Technology and Design Education, 30,* 635-656.

Please do not hesitate to contact me if you have any questions or need any additional information from me.

Sincerely,

Ezgi Yesilyurt, Ph.D.
Life Science Education
Department of Zoology
TY423 Weber State University 3848 Harrison Blvd, Ogden, UT 84408

Appendix D

INSTRUMENT PERMISSION FORM 2

Figure D.1: Instrument Permission Form 2

Konu: Re: Nature of engineering çalışması ve ölçeği hk.
Tarih: 20 Ocak 2022, Persembe, 8:07 am
Öncelik: Normal
Seçenekler: Tüm Başlıkları Göster | Yazdırılabilir Şekilde Göster | Bunu dosya olarak indir | HTML olarak göster

Merhabalar Nurseli,
Ne demek seve seve.
Ekte enstrumani ekledim.
Herhangi bir sorun olursa da her zaman ulasabilirsin.
Basarilar calismalarinda!

Kolay gelsin!

Best,
Kaya

Erdogan Kaya, Ph.D.

Assistant Professor of Education

Secondary Education (SEED) Program

Division of Elementary, Literacy, and Secondary Education

College of Education and Human Development (CEHD)

George Mason University

Sayın Erdoğan hocam,

Ben Nurseli İRDEM AĞRIMAN. Orta Doğu Teknik Üniversitesi Matematik ve Fen Bilimleri Eğitimi Bölümü Fen Eğitimi programı yüksek lisans öğrencisiyim. Prof. Dr. Jale ÇAKIROĞLU hocam danışmanlığında yüksek lisans çalışmalarımı yürütmekteyim. Nature of engineering ile ilgileniyorum.TOWARD DEVELOPING A VALID AND RELIABLE ASSESSMENT OF LEARNERS' adlı çalışamanızı inceleme fırsatı buldum. Bu çalışmanızda kullandığını ölçeğinizi kendi tez çalışmamda referans vermek kaydıyda izninizle kullanmak istiyorum. Ölçeğin orjinal halini bana ekte yollayabilirseniz ayrıca çok mutlu olurum. Yardımcı olursanız çok sevinirim hocam. Teşekkür ederim.
İyi Çalışmalar,
Saygılarımla,
Nurseli