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Analysis of the outcomes of the Turkish science curriculum in terms of science process skills, nature of science, socioscientific issues, and STEM

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Abstract

The study aimed to analyse the Turkish Science Curriculum, issued in 2018, in terms of the outcomes in different significant subjects of influence in Science Education such as, Science Process Skills (SPS), Nature of Science (NOS), Socioscientific Issues (SSI), and Science, Technology, Engineering and Mathematics (STEM). In the study, qualitative research design was utilized. The data were collected using criterion sampling method, and analysed via the document analysis method. The results show that SPS in the 2018 Science curriculum have received the greatest importance. However, the skills such as measuring, predicting and interpreting data related to SPS were largely ignored and no place was allocated to skills, such as making functional definitions and formulating hypotheses. The majority of the outcomes related to SSI were found weakly associated with them and very little emphasis was put on the structure of SSI including two dimensions/dilemmas and probability/risk. Given that special importance was attached to Science, Engineering and Entrepreneurship practices in the bases of the curriculum, whereas little space was allocated to STEM integration among outcomes. Moreover, NOS and its sub-dimensions (particularly, subjectivity, there is no single scientific method, creativity and imagination in Science) were associated with the outcomes to a small extent. The results illustrated an urgent need for the revision of the teaching objectives in the Science Curriculum in terms of integrating the subjects of SPS, SSI, NOS, and STEM.

Keywords: Science Curriculum; Scientific Process Skills; Socioscientific Issues; Nature of Science; Science, Technology, Engineering and Mathematics.

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1. Introduction

Curriculums that direct the education systems of countries have a great importance in the training of conscious and responsible citizens of the future. What is expected from the curriculum of the future is to include the outcomes, contents, educational situations, measurement and evaluation dimensions that will enable students to engage more in complex scientific events and real life problems in daily life, as in the current pandemic period.

In order to adapt to the requirements of the age, Science educators, curriculum development experts and researchers should assume great responsibilities in the development and growth of the society. As a result of the emerging scientific, social, economic, political and technological developments, for the individuals of the 21st century to be equipped with information, skills and competences, up-dating or revision of educational systems and curriculums have come to the fore as an important need (Cansoy, 2018). On the basis of 21st century skills that need to be acquired by individuals are there skills such as creativity, innovation, critical thinking and problem solving, communication and cooperation, information-media-technology literacy, life and career skills, social and intercultural skills, productivity and accountability, leadership and responsibility (Partnership for 21st Century Skills, 2019).

In order for the development of 21st century skills, it is necessary to contribute to the training of individuals who are competent of Science process skills (SPS) and are scientific literate (Turiman, Omar, Daud and Osman, 2012). SPS necessary to train individuals who can look at the world from the viewpoint of scientists, which is among the objective of Science education, can be defined as the set of skills that encourage students to conduct research, make inquiries and investigate and enable them to establish connections between daily life and Science subjects and use scientific method to deal with the problems they encounter (Tan and Temiz, 2003). They are the thinking processes that scientists use to structure information to solve problems and reach results (Özgelen, 2012). There are various classifications of SPS in the literature (Gabel, 1993; Martin, 1997; Padilla, 1990). For example, according to Martin (1997), SPS can be examined under two headings as basic skills and integrated skills. He defined observing, classifying, predicting, communicating, measuring and inferring as “basic” skills and identifying and controlling the variables, formulating and testing hypotheses, interpreting data, defining operationally, experimenting and modelling as “integrated” skills. Most Science curriculums aim to impart SPS to students (Batı and Kaptan, 2013). In the profound changes made in the Turkish Science curriculum in 2005, SPS and the sub-skills involved in their classification were strongly emphasized within the context of the objectives and outcomes in the curriculum (MEB, 2005). One of the important subjects for students to understand how scientific knowledge is constructed and the progress of Science and processes in Science is using SPS and the other is developing perceptions about the nature of Science.

The nature of Science (NOS), on the other hand, is a complex concept that includes the history of Science and the philosophical, sociological and epistemological dimensions of Science that most researchers and scientists cannot agree on. According to Bell and Lederman (2003), a citizen who can understand the structure of scientific knowledge will also distinguish true scientific claims from pseudoscientific claims by understanding the characteristics of the information and the formation process of scientific arguments, and refer to reliable scientific information on the issues they encounter in their daily life. In this respect, students should have understanding and perceptions of the NOS in order to understand the formation of scientific knowledge. The importance of the NOS in Science education has been strongly emphasized in documents worldwide as the primary component of scientific literacy, and it has been suggested that it is important for students to gain understanding on this issue (AAAS, 1993; Lederman, 1992; MEB, 2005; NRC, 1996). The basic principles created to describe NOS, in general, put emphasis on the fact that scientific knowledge is not precise, it is based on observation and experiment, it is the product of creativity, imagination and inference of individuals, is influenced by the social, political and cultural components of societies and that there are differences between scientific observation and scientific inference as well as differences between the structures of scientific theory and scientific laws (Akçay, 2014; Bell and Lederman, 2003; Doğan, Çakıroğlu, Bilican and Çavuş, 2009; Lederman, 1992; Mccomas, Clough and Almazroa, 1998). In recent years, socioscientific issues (SSI) have been emphasized as an approach that draws attention to the technological, social, environmental and health dimensions, which reveal the face of Science in daily life, in students' understanding of the NOS.

Two indispensable parts of modern Science education are the SSI and NOS (Sadler, Chambers and Zeidler, 2004; Khishfe, 2012; Zeidler et al., 2002). Sadler, Chambers and Zeidler (2004) define the relationship between these two subjects as follows: If a person can use scientific thinking process skills, he/she can understand some aspects of the NOS and if he/she resorts to SPS for individual, social and social purposes, this means that he/she thinks about SSI. SSI refer to issues which cause individuals to experience dilemmas when encountered in daily life, which individuals find difficult to decide on and on which no consensus has been reached particularly among scientists such as climate change, genetic engineering and biotechnology implementations and nuclear energy. The pandemic we are suffering from now is a good example to understand SSI. Due to the Corona virus 19 pandemic, individuals are faced with a wide variety of dilemmas and need to interpret existing scientific information and make decisions. Since the scientific event that has emerged and the scientific data regarding this event are not yet complete, people are confused about what to believe, what decision to make and how to act. Individuals' understanding of the NOS may affect their ability to interpret the scientific knowledge they use to make decisions about SSI (Sadler, 2004). Hofstein, Eilks, and Bybee (2011) pointed out the importance of integrating Science curriculums with societal problems that are a part of daily life, as in SSI, rather than content and pedagogical approaches that are unrelated to real life. As a matter of fact, SSI have taken their place in international reform documents and national curriculums (AAAS, 1993; MEB, 2013; NRC, 1996; Stolz, Witteck, Marks and Eilks, 2013).

The fourth subject focused on in the current study is Science, Technology, Engineering and Mathematic (STEM) integration. The need for the individuals who can conduct interdisciplinary works, communicate effectively and are creative in the 21st century can only be met with the generations who can blend the theoretical knowledge produced by basic Sciences such as physics, chemistry and biology and mathematics with the practices of technology and engineering to produce innovations that will add value to life (Akgündüz and Ertepınar, 2015). Although the STEM education approach was first proposed in America, it is a holistic approach that includes the integration of Technology and Engineering disciplines into the Science and Mathematics field disciplines (Bybee, 2010). STEM educators believe that by increasing the mathematics and Science requirements in schools, and by instilling technology and engineering concepts, students will perform better in their future education life and in STEM related professions (Brown, Brown, Reardon, Merril, 2011). According to Merrill (2009), STEM education can be defined as a meta-discipline in which all teachers, especially STEM teachers, teach the teaching-learning process as an integrated, interdisciplinary approach based on the standards set at school level. Content specific to this discipline is indivisible, but handled as a dynamic, fluid work. As the STEM-based curriculum includes laboratory works and project works that actively lead students to activities in groups, it contributes to the development of their 21st century skills and provides an integrated approach for them to make better decisions personally (Bybee, 2010). The STEM movement has found its place in curriculums throughout the world (ITEA, 2007; MEB, 2018; NGSS, 2013; NRC, 2011, 2013).

1.1. The State of the Four Subjects (SPS, NOS, SSI and STEM) in the 2005, 2013 and 2018 Science Curriculums in Turkey

The concept of scientific literacy has occupied an important place in the curriculums after 2005 in Turkey (Bakaç, 2019). In the 2005 Science and technology and 2013 and 2018 Science curriculums, it was stated that the basic vision is to train scientific literate individuals (MEB, 2005, 2013, 2018). Scientific and technological literacy is defined as individuals' developing their research-inquiry, critical thinking, decision making and problem solving skills, their being life-long learners, maintaining their sense of curiosity about their environment and world and as the integration of their Science skills, attitudes, values, understanding and knowledge (MEB, 2005). The scientific literacy identity includes a dynamic process that evolves throughout an individual's life.

There are some differences in terms of the distribution of learning areas and subject areas that constitute the basic structure of the 2005 Science and Technology and 2013 and 2018 Science curriculums. The seven learning areas defined in the 2005 Science and Technology curriculum are; "*Living Things and Life, Matter and Change, Physical Events, the Earth and Universe, Science-Technology-Society-Environment Interactions, Science Process Skills, Attitudes and Values"*. The following learning areas are defined in the 2013 Science curriculum; *Knowledge (Living Things and Life, Matter and Change, Physical Events, The Erath and Universe), Skills [Science Process Skills and Life Skills (Analytic Thinking, Decision Making, Creative Thinking, Entrepreneurship, Communication, Team Work)], Affect (Attitude, Motivation, Value and Responsibility) and Science-Technology-Society-Environment (SSI, the NOS, Science and Technology Relationship, Contribution of Science to Society, Awareness of Sustainable Development, Awareness of Science and Career)*. In the 2018 Science curriculum, the section defined as field-specific skills has three dimensions called *"Science Process Skills, Life Skills (Analytic Thinking, Decision Making, Creative Thinking, Entrepreneurship, Communication and Team Work) and Engineering and Design Skills (Innovative Thinking)"* while *"Living Things and Life, Matter and Change, Physical Events, the Earth and Universe"* which are addressed under the heading of learning area in the 2005 curriculum and knowledge learning area in the 2013 curriculum are addressed under the heading of subject areas in the 2018 curriculum (MEB, 2005, 2013, 2018).

SPS are addressed under the heading of learning areas in the 2005 Science and technology curriculum, under the heading of skills in the 2013 Science curriculum and under the heading of field-specific skills in the 2018 Science curriculum (MEB, 2005, 2013, 2018). In all the three curriculums, some outcomes belonging to the living things and life, matter and change, physical events and the earth and universe learning areas or subject areas are presented to practitioners as integrated with SPS. However, only in the 2005 Science and technology curriculum, SPS are emphasized by being separately labelled among the outcomes (MEB, 2005).

When the related statements regarding the NOS in the 2005 Science and technology curriculum and the 2013 and 2018 Science curriculums in Turkey are examined, the following general conclusions can be reached: In the 2005 Science and technology curriculum, there is no statement regarding the NOS (MEB, 2005). However, in the curriculum, there is a heading called *"the Nature of Science and Technology"* and related to the Science-Technology-Society learning area. Under this heading, not the NOS, but the features of science and scientific knowledge are explained (Özden and Cavlazoğlu, 2015). In the 2013 and 2018 Science curriculums, there is the following statement referring to the NOS *"helping understand how scientific knowledge is created by* *scientists, the processes through which this information is created and how it is used in new research"* in the objectives of the curriculum (MEB, 2013, 2018). In the 2013 curriculum, the concept of the NOS in emphasized in the Science-technology-society-environment relationships dimension. In the 2018 curriculum, the Science-technology-society-environment relationships dimension was completely removed from the scope of the field-specific skills targeted by the curriculum and there is no emphasis on the NOS in the learning areas content of the program except for the objectives in the curriculum regarding the NOS.

SSI were first included in the 2013 Science curriculum in Turkey. Development of students' scientific thinking habits by teachers using SSI is one of the goals of curriculums. Moreover, SSI addressed within the context of the Science-Technology-Society and Environment learning area are defined as follows: *"They cover the scientific and ethical reasoning skills required for the solution of Science and technology-related socioscientific problems (MEB 2013, p. 6)"*. Similarly, the following explanation regarding SSI is given in the special objectives of the 2018 Science curriculum; "*Developing reasoning, scientific thinking and decision making skills by using socioscientific issues"*. The Science-Technology-Society-Environment relationships learning area in the 2013 Science curriculum is not included in the 2018 Science curriculum and SSI are not handled within the context of either learning areas or subject areas.

The concept of the STEM education approach was first included in the 2018 Science curriculum in Turkey. In the 2018 Science curriculum, the necessity of imparting engineering and design skills to students is emphasized within the scope of field-specific skills. Engineering and design skills are defined as follows;

> *"They are skills enabling students to integrate Science, technology and engineering, to gain interdisciplinary perspectives towards problems, to reach the scientific level where they can make inventions and innovations and to create some products by using the knowledge and skills they have gained and to develop strategies to add values to these products* (MEB, 2018, p.10)".

Science, engineering and entrepreneurship implementations are handled as a separate title in the 2018 curriculum and its importance is emphasized in detail. Within the scope of Science, engineering and entrepreneurship implementations in the curriculum, the following is expected from the students in the most general terms. They are expected to define a need or a problem from daily life related to the subjects studied in the units. In the solution of a problem, students compare alternative ways of solution and select the most suitable one on the basis of the criteria (MEB, 2018). Then they are expected to make plans on the selected solution and to create and present the product. They are required to create strategies to market the product and to make use of the tools of promotion. In the 2018 Science curriculum, students are required to be engaged in Science, engineering and entrepreneurship implementations and to present the product they have produced as a result of these implementations at the end-of-year Science festivals. Separate class hours are allocated to Science, Engineering and Entrepreneurship implementations in the curriculum in each grade level except for the 3rd grade level (9 class hours in the 4th grade and 12 class hours in the 5th, 6th, 7th and 8th grades) (MEB, 2018).

Above is given the current state of the subjects "SPS, NOS, SSI and STEM" on the basis of the expressions found in the following sections of the 2005 Science and technology curriculum and 2013 and 2018 Science curriculums; the outcomes of the curriculum, learning areas and skills aimed to be imparted to students. In the current study, within the context of the outcomes of the 2018 Science curriculum, it was aimed to analyze and evaluate the subjects of "SPS, NOS, SSI and STEM". In the literature, there are studies focusing on the individual analysis of these subjects in curriculums and comparison of their places in new and old curriculums (Bağcı Kılıç, Haymana and Bozyılmaz, 2010; Bakaç, 2019; Özgelen, 2012; Şardağ et al., 2014; Topçu, Muğaloğlu and Güven, 2014). Yet, what makes the current study different from other studies and original is its using the 2018 Science curriculum as the source of data, its inclusion of the analysis of the NOS and SSI in the curriculum, its addressing four different important educational subjects together. To this end, answers to the following research questions were sought;

1- What is the distribution of the outcomes related to SPS and sub-skills across the grade levels in the Science curriculum issued in 2018?

2- What is the distribution of the outcomes related to the NOS and its sub-dimensions across the grade levels?

3- What is the level of association between SSI and outcomes in the curriculum?

4- What is the distribution of the outcomes about sub-dimensions of SSI across the grade levels?

5- What is the distribution of the outcomes related to STEM integration across the grade levels?

6- What is the comparative distribution of the subjects of SPS, SSI, STEM and NOS?

2. Method

The purpose of the study was to analyse the subjects of "SPS, NOS, SSI and STEM" within the context of the Science Curriculum approved in 2018 by Ministry of National Education Board of Education, Turkey. The study adopted qualitative research design and the data were analysed via document analysis method. According to Bowen (2009), documents are printed or electronically recorded text or images not influenced by the researcher in anyway. Like other analytic methods in qualitative research, document analysis includes systematic procedures based on reviewing and evaluating documents to reveal meaning or understanding. Documents used in qualitative research can be official or personal, sometimes they constitute the main data of the research and sometimes support the research as supplementary data (Bryman, 2004; Güler, Halıcıoğlu, Taşğın, 2015). The 2018 Science curriculum used in the current study is an official document and constitutes the main data source of the study.

1.2. Data Source and Analysis Process

The study utilized criterion sampling method, one of the purposive sampling methods. In criterion sampling, objects, situations, events or texts that meet the criteria that emerge depending on the purpose of the research and the problem statements can be included in the sample (Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz and Demirel, 2008; Palinkas et al., 2015). The main data source of the study is the 2018 Science curriculum (elementary and secondary school 3rd, 4th, 5th, 6th, 7th and 8th grades) issued by the Board of Education of the Ministry of National Education, Turkey. Depending on the criterion sampling method, four subjects analysed in the study (SPS, NOS, SSI and STEM) were examined according to the outcomes of the relevant curriculum. The criterion used for the inclusion in the sample is the document's having an outcomes of the curriculum. In the process of data analysis, the stages described by Forster (1995) as reaching and checking the document, understanding the document, analysing and digitizing the data and presenting the data (Yıldırım and Şimşek, 2008) were used.

- ✓ *Reaching out and checking the documents:* In the current study, the documents were obtained in the PDF format directly from the web address belonging to the Ministry of National Education (http://mufredat.meb.gov.tr/). The obtained documents were official, original and reliable.
- ✓ *Understanding the documents:* In order to be able to examine the 2018 Science curriculum documents within a certain system, the outcomes were selected one by one and transferred to an excel file. For the four subjects (SPS, NOS, SSI and STEM) selected in line with the purpose of the study, the documents were revised again and again, taking into account the definitions in the literature.
- ✓ *Analysing the documents:* In this process, the sentences and the vocabulary in the curriculum's judgment statements for the subject of Science process skills were coded according to the stages suggested by Martin (1997) as observing, classifying, predicting, communicating, measuring, inferring, defining and controlling variables, formulating and testing hypotheses, interpreting data, defining operationally, experimenting and modelling. An example for the coding process is given below.

Table 1. An example for the coding process of the outcomes in the Science curriculum related to SPS

Outcomes	**Indicators**	**Code**
F.4.3.2.1. Recognizes the magnet and discovers that it has poles. F.6.3.1.3. Compares balanced and unbalanced forces by observing the motion conditions of objects.	Discovering and Observing	Observing
F.8.2.5.3. Makes predictions about what engineering and biotechnological implementations might be in the future.	Predicting	Predicting
F.6.1.1.1. Compares the planets in the solar system with each other. F.7.3.2.2. Classifies energy as kinetic and potential energy by associating it with the concept of work.	Comparing and Classifying	Classifying
F.5.3.1.1. Measures the magnitude of the force with a dynamometer.	Measuring	Measuring
F.4.4.5.3. Discuss the separation of mixtures in terms of contribution to the country's economy and efficient use of resources. F.5.6.2.2. Present suggestions for the solution of an environmental problem in his/her immediate surroundings or in our country.	Discussing and Presenting	Communicating
F.3.5.3.1. Concludes that every sound has a source and that the sound spreads in all directions. F.8.4.5.4. Relates the state changes in daily life to heat exchange. F.7.1.1.5. Makes inferences about the importance of the telescope in the development of astronomy.	Relating, making inference, draw a conclusions	İnferring
F.8.4.5.1. Discovers by experiment that warming depends on the type, mass and / or temperature change of the material. F.8.3.1.2. Predicts and tests the variables that affect fluid pressure.	Predicting and testing variables, discovering… that it depends on the change of	Defining and controlling variables
F.5.4.1.1. Makes inferences based on the data obtained from his/her experiments that matters can change their state with the effect of heat. F.8.4.5.3. Interprets the state change and warming of matters by drawing their graph. F.8.6.4.4. Offers solutions using research data on the contribution of recycling to the national economy. F.5.4.3.2. Interprets the results by making experiments showing that there is heat exchange as a result of mixing liquids with different temperatures.	Making inferences based on data, interpreting by drawing a graph proposing suggestions by using data, interpreting the result by conducting experiments	Interpreting data
F.3.3.2.1. Discovers by experimenting that pushing and pulling are forces. F.6.4.2.3. Compare the densities of liquids not dissolving within each other by experimenting. F.6.4.2.2. Calculates the densities of various matters as a result of the experiments he/she has designed.	Discovering through trial with the experiments, comparing through experimenting.	Experimenting
F.6.1.2.3. Creates a model representing the Sun and Lunar eclipse. F.6.5.4.5. Makes a design of an environment that will serve as an example for sound insulation or acoustic implementations. F.7.7.1.6. Designs an original lighting tool.	Creating model, making designs.	Modelling

The second problem statement of the current study is related to the analysis of the outcomes in the 2018 Science curriculum in terms of the NOS and for this purpose, the codes found in the NSTA (2000) document regarding the NOS and used by Şardağ et al. (2014) and Özden and Cavlazoğlu (2015) were examined and used. Science as a way of knowing, the tentativeness of scientific knowledge, there is no single scientific method, the role of imagination and creativity in Science, subjectivity in Science, theory and laws as a type of scientific knowledge, scientific prediction and theoretical assumptions, the relationship between Science and technology, and the sociocultural context of Science have been used as sub-dimensions of the NOS

Table 2. An example for the coding process of the outcomes in the Science curriculum related to NOS

Outcomes	The dimension of the NOS
F.3.1.1.1. Realizes that the shape of the earth is like a sphere.	The tentativeness of scientific knowledge
a. Past views on the shape of the earth are stated.	
F.7.4.1.2. Questions how the ideas about the concept of atom have changed from past to present.	Theory and laws as a type of scientific knowledge
c. General information about the theory, one of the types of scientific knowledge, is given.	
F.4.5.1.1. Compares the lighting tools used in the past and today.	Science and technology relationship
F.8.2.5.2. Discusses the dilemmas emerging within the context of biotechnological implementations and useful and harmful aspects of these implementations for humanity.	Sociocultural context of Science
F.8.6.3.3. Discusses the causes and possible consequences of global climate changes.	Scientific prediction and theoretical assumptions
F.8.1.2.2. Says that climatology is a branch of Science and that experts working in this field are called climatologists.	Science as a way of knowing

The second problem statement of the current study related to outcomes concerning SSI were coded on the basis of the responses given to the following questions.

- ✓ Question 1: Does it include at least one of the Science & Technology & Society & Environment & Health (STSEH) interactions?
- ✓ Question 2: Does it include two dimensions/aspects (benefit/harm, advantage/disadvantage etc.) or a dilemma?
- ✓ Question 3: Does/Do the concept(s) in the outcomes cause any controversy in the society?
- ✓ Question 4: Does it cause people to exhibit different behaviours depending on ethical, moral, emotional or environmental value judgements?
- ✓ Question 5: Does it require any probability/risk or economic evaluations?

The first of the questions given above is a pre-requisite for an outcome to be related to SSI. The learning outcome for which the answer to the first question is “Yes” were evaluated in terms of the 2nd, 3rd, 4th and 5th questions. If the answers to at least two questions are "Yes", then this learning outcome was coded as including a SSI dimension and having a weak association. If the answers to three questions are "Yes", then the learning outcome can be moderately associated with SSI; if the answers to four questions are "Yes", then it can be associated with SSI good and if the answers to five questions are "Yes", then it can be associated with SSI very good. A sample coding and explanation are given below:

Table 3. An example for the coding process regarding the relationship of the outcomes in the Science curriculum with SSI

Outcomes	Question 1	Question 2	Question 3	Question 4	Question 5	Evaluation
F.4.5.4.2. Investigates the positive and negative effects of technological tools having loud noise.	X	X	□	□	□	Weak association with SSI
F.5.6.2.4. Discusses the benefits and harms of human-environment interaction with examples.	X	X	X	□	□	Moderate association with SSI
F.8.7.3.5. Discusses the importance of the conscious and economical use of electrical energy in terms of family and country economy.	X	□	X	X	X	Good association with SSI
F.8.2.5.2. Discusses the harmful and useful aspects of biotechnological implementations over dilemmas created within the scope of these implementations.	X	X	X	X	X	Very good association with SSI

In order to find an answer to the third problem of the current study, in the coding of the outcomes indicating Science, technology, engineering and mathematics integration, the outcomes including value judgements such as creates solutions/new ideas; designs/creates projects/mechanisms/products/models were coded as related to the STEM approach. A sample coding and explanations are given below.

Table 4. *An example for the coding process* related to the relationship of the outcomes in the Science curriculum with STEM

Outcomes	Indicators
F.3.6.2.4. Designs an artificial environment.	… designs
F.5.3.2.3. Generates new ideas to increase or decrease friction in daily life.	… generates ideas
F.6.4.3.3. Develops alternative thermal insulation materials.	…develops
F.7.4.5.2. Designs a project regarding the recycling of domestic solid and liquid wastes.	…designs projects
F.8.7.3.2. Designs a model based on the conversion of electrical energy into heat, light and motion energy.	…designs models

* Digitizing and presenting the data: After the data were coded, they were checked for the repeated codes and thus frequency tables were created and in order to facilitate the understanding of these tables for other researchers and readers, they are presented in graphs and interpreted.

3. Results

3.1 Results related to analysis of the outcomes in the Science curriculum in terms of SPS

Of the 305 outcomes in the Science curriculum, 207 (67.8%) were found to be within the subject of SPS. The following findings were obtained when the outcomes concerning SPS were evaluated under the sub-subjects of basic process skills and integrated process skills.

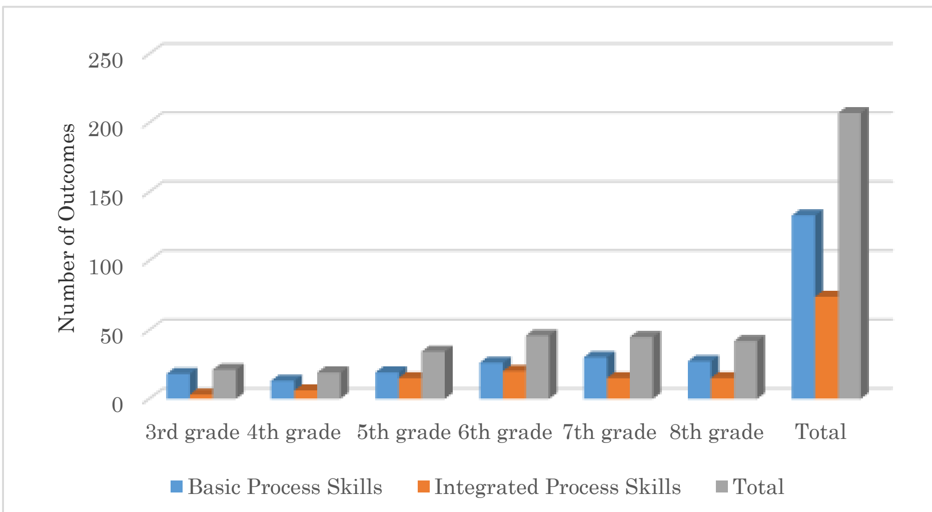

Figure 1. The distribution of the outcomes related to basic and integrated process skills across the grade levels

Within the scope of the curriculum, it was found that a greater emphasis is put on the basic process skills (the number of outcomes: 133; 64.2%), and the number of outcomes that include basic process skills has an increasing trend starting from the 3rd grade towards the 5th, 6th and 7th grades yet it partially decreases in the 8th grade. It was determined that the number of the outcomes including integrated process skills (the number of outcomes: 74; 35.7%) tends to increase from the 3rd grade towards the 4th, 5th and 6th grade levels, and partially decreases at the 7th and 8th grade levels. When the codes belonging to the sub-subjects of basic process and integrated process skills were examined, the following findings were obtained.

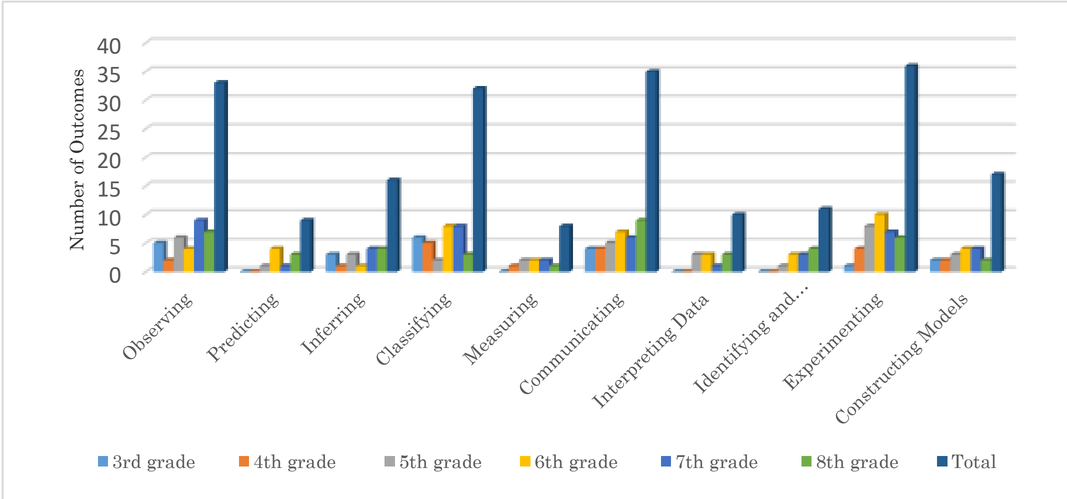

Figure 2. The distribution of the outcomes related to sub-subjects of SPS across the grade levels

As can be seen in Figure 2, a greater emphasis is put on the basic process skills of observing (the number of outcomes: 33; 15.9%), classifying (the number of outcomes: 32; 15.4%) and communicating (the number of outcomes: 35; 16.9%). On the other hand, from among the integrated process skills, a greater emphasis is put on the skill of experimenting (the number of outcomes: 36, 17.3%). Less emphasis is put on the basic process skills of predicting (the number of outcomes: 9, 4.3%) and measuring (the number of outcomes: 8; 3.8%) and on the integrated process skills of interpreting data (the number of outcomes: 10, 4.8%) and defining and testing the variables (the number of outcomes: 11; 5.3%) in the 2018 Science curriculum. Moreover, the integrated process skills of formulating hypotheses and making operational definitions are not included in the Science curriculum for any grade level.

3.2 Results related to analysis of the outcomes in the 2018 Science Curriculum in terms of the NOS

When the outcomes in the 2018 Science curriculum were examined in terms of NOS, a total of 13 (4.2%) outcomes were reached. No learning outcome associated with the NOS was encountered in the 4th and 6th grade levels. The distribution of the codes concerning the NOS and its sub-dimensions across the grade levels in the curriculum is given below.

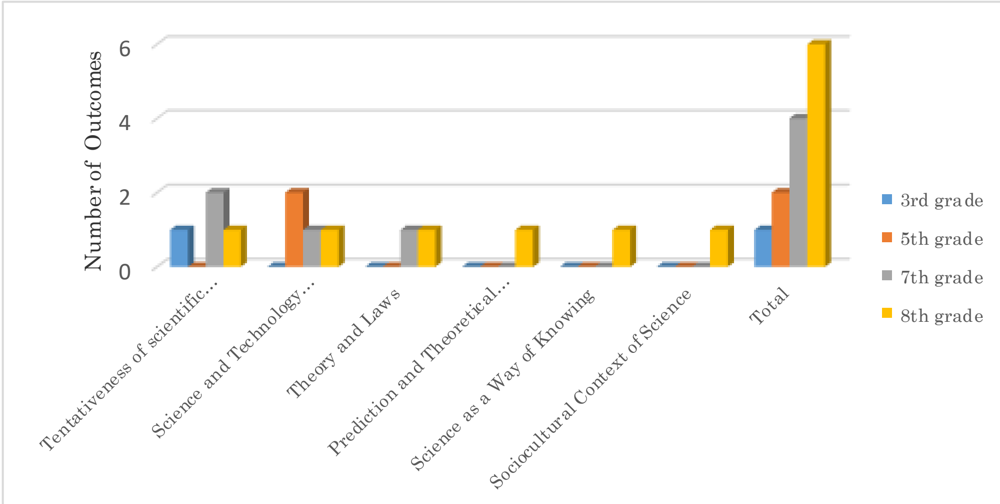

Figure 3. The distribution of the outcomes related to the NOS and its sub-dimensions across the grade levels

As can be seen in Figure 4, the association of the outcomes in the curriculum with the NOS increases with the increasing grade level. The highest number of the outcomes related to the NOS was found in the 8th grade level (the number of outcomes: 6; 46.1%). Within the context of the curriculum, the most strongly emphasised dimensions of the NOS were found to be the tentativeness of scientific knowledge (the number of outcomes: 4; 30.7%) and Science-technology relationship (the number of outcomes: 4; 30.7%). The least emphasized dimensions of the NOS were found to be the sociocultural context of Science (the number of outcomes: 1; 7.6%), Science as a way of knowing (the number of outcomes: 1; 7.6%) and scientific prediction and theoretical assumptions (the number of outcomes: 1; 7.6%). The dimensions of the NOS defined as subjectivity in Science, there is no single scientific method, imagination and creativity in Science in the NSTA (2000) document are not included in the SC.

3.2 Results related to analysis of the outcomes in the 2018 Science Curriculum in terms of the SSI

Of the 305 outcomes in the curriculum, 34 (11.1%) were found to have some emphasis on SSI. The level of the association of the outcomes in the curriculum with SSI was scored on the basis of the questions mentioned in the data analysis section and they were classified into the categories of weak, moderate, good and very good. The graph related to these data is presented below.

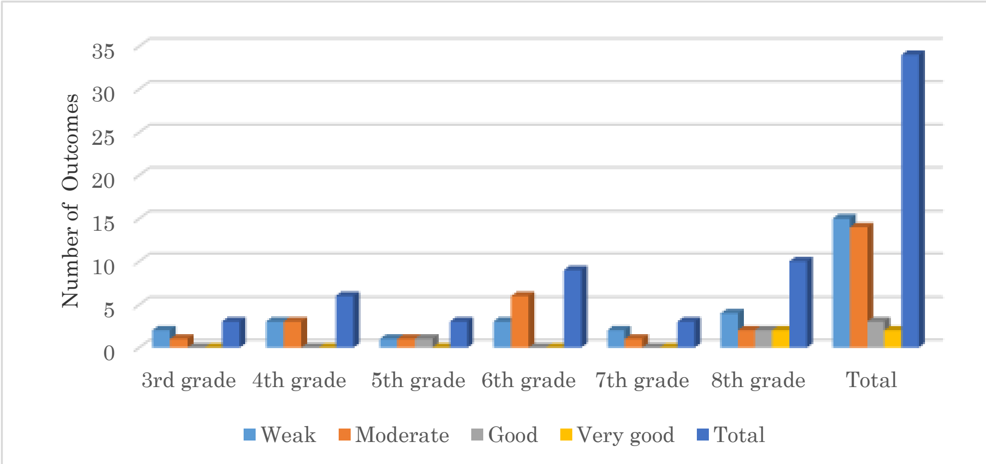

Figure 4. The distribution of the levels of the association of the outcomes with SSI across the grade levels

As can be seen in Figure 4, though SSI are included in each grade level, the highest number of the outcomes is found in the 6th grade level (the number of outcomes: 9; 26.4%) and in the 8th grade level (the number of outcomes: 10; 29.4%). SSI are mostly expressed through association with outcomes weakly (the number of outcomes: 15; 44.1%) and moderately (the number of outcomes: 14; 41.1%). The increasing and decreasing tendency of the outcomes related to SSI across the grade levels was found to be varying. Though there are some outcomes that can be associated with SSI at a good level (the number of outcomes: 3; 8.8%) and at a very good level (the number of outcomes: 2, 5.8%), there is no objective associated with SSI at a very good level in the 8th grade. The distribution of the outcomes emphasising SSI across the components of SSI is below.

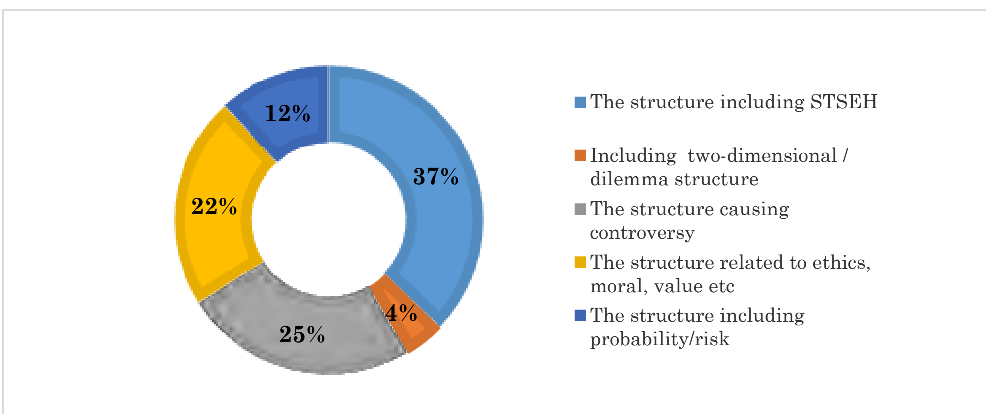

Figure 5. The distribution of the outcomes related to components of SSI

As can be seen in Figure 5, the outcomes related to SSI in the curriculum were found to largely include two or more of the interactions between Science, technology, society, environment and health (STSEH) (37%). Little emphasis is put on the components of including dilemmas/two dimensions (4%) and probability/risk evaluation (12%) in the relevant outcomes.

3.4 Findings related to analysis of the outcomes in the 2018 Science Curriculum in terms of STEM

When the outcomes in the curriculum were examined in terms of STEM, a total of 21 (6.8%) outcomes were found to be related to STEM skills. When the distribution of the relevant outcomes across the grade levels was examined, the following pie chart was obtained.

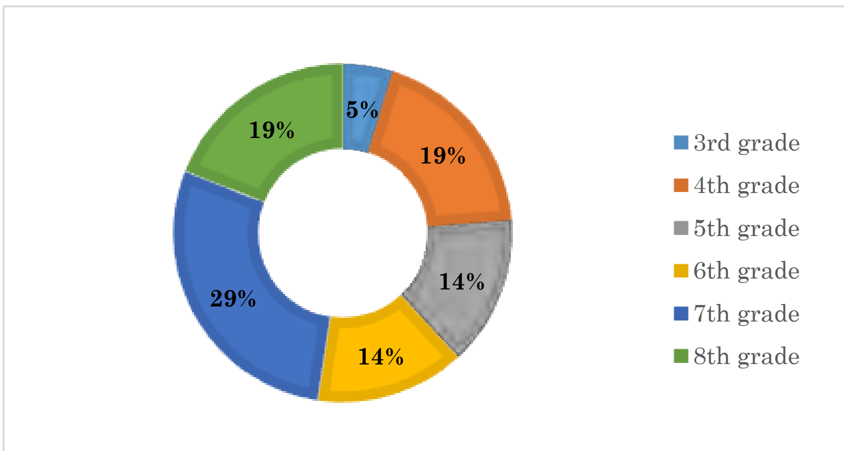

Figure 6. The distribution of the outcomes related to STEM skills across the grade levels

As can be seen in Figure 6, the tendency in the increase and decrease of the outcomes related to STEM varies across the grade levels. The highest number of STEM-related outcomes was found in the 7th grade level (the number of outcomes: 7; 29%) while the lowest number of outcomes was found in the 3rd grade level (the number of outcomes: 1; 5%).

3.5 Findings related to the comparison of the outcomes in the 2018 Science Curriculum in terms of four subjects

Findings related to the comparison of the subjects of SPS, NOS, SSI and STEM in the 305 outcomes found in the Science curriculum according to grade level are presented in Figure 7.

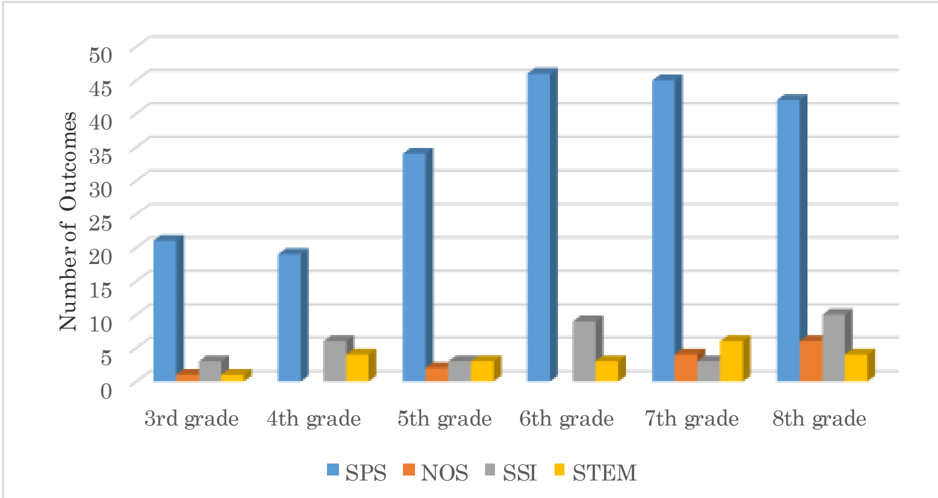

Figure 7. The distribution of the four subjects (SPS, NOS, SSI and STEM) in the 2018 Science curriculum across the grade levels

As can be seen in Figure 7, the subject most strongly emphasized in the Science curriculum at both elementary and secondary school levels is SPS (number of outcomes: 207; 75%). The subject least emphasized on the other hand is the NOS (number of outcomes: 13; 4.2%) and although strongly emphasized in the bases of the curriculum, STEM is not much emphasized in the outcomes of the curriculum (number of outcomes: 21; 6.8%). The level of inclusion of SSI in the outcomes of the 2018 Science curriculum was also found to be low (number of outcomes:34; 11.1%) and the association of many of these 34 outcomes (number of outcomes:15; 44.1%) with SSI remained weak.

3. Discussion

According to the results of the study, considerable emphasis is put on SPS in the outcomes of the Science Curriculum issued in 2018 in Turkey. More place is allocated to the basic process skills than the integrated process skills in each grade level in the curriculum. While the greatest attention is paid to the basic process skills of observing, communicating and inferring, the greatest attention is paid to the integrated skill of experimenting in the curriculum. Similarly, Özcan and Koştur (2019) reported that the Science curriculum attaches great importance to SPS within the context of the field-specific skills. Bağcı Kılıç, Haymana and Bozyılmaz (2008) investigated the 2004 Science and technology curriculum in terms of Science literacy and SPS and concluded that more place is allocated to basic process skills and great emphasis is put on observing, comparing and inferring while less emphasis is put on communicating, predicting, classifying and measuring. Thus, it can be said that in both the Science and Technology curriculum issued in 2004 and the Science curriculum issued in 2018, less emphasis is put on predicting and measuring skills yet as the curriculums analyzed in the two different studies are different, there are conflicts in the results of the studies regarding communicating and classifying skills. Moreover, in the study conducted by Bağcı et al. (2008), it was also found that there are no outcomes focused on the skill of formulating and testing hypotheses in the 2004 Science and technology curriculum. Although great importance is attached to SPS in the 2018 Science curriculum, some basic process skills such as measuring, predicting and some integrated process skills such as defining operationally, interpreting data and formulating and testing hypotheses seem to be largely ignored. In the study conducted by Bakaç (2019) to comparatively investigate the general objectives of the 2005 Science and technology curriculum, 2008 and 2018 Science curriculums, it was concluded that all the programs include objectives directed to the training of students as individuals who can make use of scientific methods, can look at the world from the eye of a scientist and can effectively use SPS. Duruk, Akgün, Doğan and Gülsuyu (2017) investigated the distribution of SPS across the grade levels in the 2013 Science curriculum and found that there are no outcomes addressing the skills of making operational definitions and formulating hypotheses while great emphasis is put on the observing and communicating skills. Moreover, they found that little emphasis is put on basic processes related to the skills of measuring and predicting. While measuring is defined as engaging in the acts of comparing and counting (Tan and Temiz, 2003), predicting is defined as putting forth anticipations about an event or a situation that may occur in the future before the event actually happens (Aslan, Ertas Kılıc and Kılıc, 2016; Martin, 1997). Both measuring and predicting are extremely important basic Science process skills. However, the measuring skill is not emphasized adequately in Science classes and is generally neglected in schools (Maral, Oğuz Ünver and Yürümezoğlu, 2012). In light of the findings of the current study, it can be said that the most important reason for this inadequate emphasis is that not enough place is allocated to the basic process skills of measuring and predicting in the outcomes of elementary and secondary Science curriculums. The basic process skills and integrated process skills that most emphasized, ignored and completely overlooked in the Science curriculum are presented in Figure 1.

According to the results of the current study, there are few outcomes focused on the nature and functioning of Science in the 2018 Science curriculum. While the greatest emphasis is put on the tentativeness of scientific knowledge as one of the components of the NOS, very little emphasis is put on the components of Science as a way of knowing and the sociocultural context of Science. On the other hand, there are no outcomes in the Science curriculum focused on the following components of the NOS; the inferential and theoretical dimension of scientific knowledge, subjectivity in Science, there is no single scientific method, creativity and imagination in Science; thus, they are completely overlooked in the curriculum. Similarly, Özden and Cavlazoğlu (2015) concluded that very little place is allocated to the direct instruction of the components of the NOS and some components are not even mentioned in the 2005 and 2013 Science curriculums. In their study, Şardağ et al. (2014) found that in the high school curriculums of physics, chemistry and biology, the emphasis put on the dimensions related to the NOS such as sociocultural context of Science, creativity in Science and subjectivity in Science is very little. Laçin Şimşek (2009) analyzed the 2005 Science and technology curriculum and textbooks in terms of the history of Science and parallel to the current study, found that very little emphasis is put on the sociocultural context of Science such of the psychology and social effects of Science. However, as different from the current study, they stated that very little place is allocated to the tentativeness of scientific knowledge in Science and technology textbooks. This might be because of the fact that the textbooks used in Science classes in 2005 were prepared on the basis of the outcomes of the 2005 Science and technology curriculum and the analyzed data sources are different. The inadequate emphasis put on the outcomes related to the NOS and its components in the 2005 Science and technology curriculum and 2013 Science curriculum of elementary and secondary schools and high school curriculums of physics, chemistry and biology seem to remain the same in the 2018 Science curriculum.

The third subject investigated in the current study is the level of association between the outcomes in the 2018 Science curriculum and SSI. In this regard, it can be argued that the level of association between the outcomes in the 2018 Science curriculum and SSI is weak, which may cause Science teachers to superficially deal with SSI in their classes. Demir (2019) concluded that SSI and how these issues can be instructed are inadequately addressed in Science textbooks and curriculums. Topçu, Muğaloğlu and Güven (2014) emphasized that while SSI are theoretically emphasized in the 2013 Science curriculum, they are not much emphasized in practice and this may cause some problems. Erduran Avcı and Önal (2012) pointed out that the great majority of the least frequently repeated objectives in the Science and technology curriculum are related to human-society-technology issues. Similarly, in the current study, weak associations were found between the outcomes in the 2018 Science curriculum and SSI which were first introduced to Science education with the 2013 Science curriculum. Özcan and Coştur (2018) also analyzed the same document used in the current study within the context of special objectives and field-specific skills and found that there are only two outcomes related to SSI and pointed to the inadequate emphasis put on these issues. In the current study, the number of outcomes strongly associated with SSI was also found to be two. In these two outcomes, the emphasis is put on Science & Technology & Society & Environment & Health interactions, two-dimensional structure of SSI such as benefit/harm, advantage/disadvantage, the fact that SSI cause controversies in the society and the fact that people can exhibit different behaviors depending on their ethical, moral, emotional and environmental value judgements. The number of the outcomes strongly associated with SSI was found to be very low in the current study. When the 34 outcomes considered to be related to SSI in the current study were examined in terms of the components used to determine whether an outcomes is related to SSI and mentioned in the sample coding section, it was concluded that these outcomes are mostly directed to SSI including Science & Technology & Society & Environment & Health interactions and its controversial structure while the number of the outcomes emphasizing the structure of SSI including dilemmas and probability/risk evaluation is very small.

The fourth subject examined in the current study is the integration of Science-technology-engineering and mathematics (STEM), which started in America and was adopted all over the world, to meet the need of training individuals who can work interdisciplinary. The STEM approach was first included in the 2018 Science curriculum. The STEM approach is included in the 2018 Science curriculum under the heading of Science, mathematics and entrepreneurship implementations and in the curriculum they are required to be taught in each grade level except for the 3rd grade level (9 class hours in the 4th grade and 12 class hours in the 5th, 6th, 7th and 8th grades) and students are expected to present the product they have produced as a result of these implementations at the end-of-year Science festivals (MEB, 2018). When the outcomes in the 2018 Science curriculum were examined in terms of STEM, a total of 21 (6.8%) outcomes were found to be related to STEM skills. In light of this finding, it can be said that although Science, engineering and entrepreneurship skills are emphasized in the 2018 Science curriculum on a theoretical basis, they remain insufficient in terms of being addressed by the outcomes in the curriculum, which may cause problems in practice. In their study, Bahar et al. (2018) investigated the same document used in the current study in terms of the changes in the outcomes and STEM integration and reported similar results. They stated that although there are different outcomes that can be evaluated within the context of STEM, the reflection of the issues emphasized in the introduction part of the curriculum on the outcomes stated in the curriculum is controversial. Different from the current study, Özcan and Koştur (2019) determined that 11 outcomes located within the scope of the field-specific skills are related to engineering skills and emphasized that the number of the outcomes addressing STEM is lower than the number of outcomes related to SPS and life skills. The reasons for different findings obtained in the two studies might be because of the use of different codes and subjects due to the nature of qualitative research. Saraç and Yıldırım (2019) stated that teachers are of the opinion that the Science, engineering and entrepreneurship implementations are not associated with the outcomes in the 2018 Science curriculum and believe that teaching these implementations is challenging.

When the comparative distribution of the outcomes regarding SPS, NOS, SSI and STEM integration in the 2018 was examined in the current study, it was seen that the curriculum largely aims to develop SPS in elementary and secondary school students yet the outcomes related to the NOS and its components are ignored to a great extent. Moreover, although the concept of STEM is not directly used in the curriculum, such integration is emphasized in the explanations related to Science, engineering and entrepreneurship dimensions of the curriculum in the introduction part of the curriculum but not in the outcomes of the curriculum. Though the outcomes addressing SSI are moderately emphasized in the 2018 Science curriculum, the association between the outcomes and SSI was found to be weak in general. Thus, there is a need to update the outcomes aiming to develop students' understanding of the NOS, to foster students' versatile thinking skills including the integration STEM and to make them more sensitive towards SSI like the ones arousing during the pandemic.

4. Conclusion and Recommendations

The study shows that Science process skills in the 2018 Science Curriculum have received the greatest importance in Turkey. This can be seen as one of the positive aspects of the curriculum. However, although more importance is attached to the basic process skills in the curriculum, skills such as predicting and measuring are overlooked to a great extent. In this regard, addition of more outcomes related to the skills of predicting and measuring or the balance between the outcomes in terms of addressing different skills should be established. While no objective related to the integrated process skills of making operational definitions and formulating hypotheses was found in the curriculum, few outcomes were detected concerning the skills of interpreting data and defining and testing the variables. These integrated process skills which are not much emphasized or completely ignored in the curriculum and which are as important as the basic process skills should be addressed by more outcomes in the curriculum. Another results of the study, NOS and STEM integration of outcomes are very few emphasized in the curriculum. Especially, dimensions of NOS such as subjectivity, there is no single scientific method, imagination and creativity in Science were not included in the curriculum. In the future revision of Science course curriculum, these components of NOS related to the outcomes should be added to increase their number. Thus, elementary and secondary schools' students are gained experience about these dimensions of NOS as well as SPS. On the other hand, integration of STEM is very frequently emphasized in the special objective of the current curriculum under the title of Science, engineering and entrepreneurship, but it is not considered very important in the outcomes which are the starting point of the implementations in the Science class. In this respect, it can be suggested to emphasize and increase the outcomes related to STEM. Another subject in the study is status and level of including SSI related to outcomes. Although the curriculum in the study seems to include moderate SSI, the way that most of the outcomes are related to SSI are at a very poor level. In this respect, the outcomes related to SSI in the current curriculum should be reviewed. The two-dimensional structure of SSI such as benefit / loss, advantage / disadvantage and their requiring probability / risk evaluation should be emphasized in the outcome statements.

In the current study, the 2018 Science curriculum was analyzed according to four subjects. Future research can focus on the investigation of other skills and other subjects such as entrepreneurship, career consciousness, attitude etc. in the curriculum. Moreover, studies can be conducted on the reflections of the subjects analyzed on the textbooks. Furthermore, opinions and suggestions for practices of teachers, pre-service teachers and Science education researchers can be obtained about the Science curriculum.

Undoubtedly, the primary practitioners of the curriculum are teachers and the future practitioners are pre-service teachers. On the basis of the findings obtained in the current study, it can be recommended that activities should be designed or unit modules should be developed to better teach the outcomes related to the subjects of SPS, the NOS, SSI and STEM. By using the codes of the qualitative analysis method, teachers and pre-service teachers can determine and draw on teaching methods, techniques and approaches, such as the Prediction, Observation and Explanation techniques.

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