DEVELOPMENTS IN THE FIELD OF SCIENCE EDUCATION IN TURKEY BETWEEN 2000-2020

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INTRODUCTION

The end of the 1900s and the beginning of the 2000s have been the years of rapid technological developments. In this century, space telescopes produced with advanced technology, irradiation research, facial and stem cell transplants, organs produced artificially with 3D technology, tools developed through nano technologies, artificial intelligence research, the discovery of new living species and discovery of gravitational waves, the longest duration on Mars, the construction of unmanned spacecraft that can last for a long time, the discovery of water on Mars, the production of robotic body parts, the discovery of treatment methods against the HIV virus, the production of heart tissue from skin cells, the discovery of the use of water as fuel, face transplantation, smart books, wireless internet and electronic mobile books and many other scientific developments attracted attention (Sakız, 2018). These rapid changes in science and technology, changes in the needs of the individual and society, developments and innovations in learning approaches have also affected the roles expected from individuals (Ayvacı, Er Nas, & Kirman Bilgin, 2020a). Therefore, this situation has led to changes in the understanding of teaching, in curricula and the training of teachers who are practitioners of these programs. In this context, the present study aims to examine the changes that took place between 2000-2020 in the approaches of science teaching and consequently the changes in science programs and in the education of science teachers.

Changes and Developments in Science Programs

When the science curricula (1924, 1926, 1931, 1937, 1938, 1948, 1969, 1974, 1977, 1983, 1992, 2000, 2005, 2013, 2017, 2018) from 1922 to the present are examined, it is seen that these programs have undergone many changes. These changes were sometimes rooted like the 2005 program and sometimes included minor revisions like the 2013 program. In this study, science teaching programs between the years 2000-2020 (2000, 2005, 2013, 2017, 2018) were examined.

2000 Primary School Science Curriculum

In this program, the name of the course remained as "Science" as in the 1992 program.

It has been stated that one of the goals of the program is to raise science literate individuals. One of the most basic features of this program is that besides the objectives, the acquisition dimension has been added to the program. Thus, the program focused on student acquisitions. However, according to the 1992 science curriculum, the subject domain was limited and subjects related to Kemalism were also included in the program. Biology in the sixth and eighth grades and physics in the seventh grade were included in the program (Çepni & Çil, 2015). Together with this, physics experiments were mostly included in this program, and it was stated that physics experiments could not be done adequately due to the insufficient duration of the course and the experimental materials at schools (Bozdoğan, 2003). The program is based on the concept of constructivism. The measurement and evaluation dimension, which was limited in the 1992 program, was given more importance in the 2000 program. It was emphasized that students should not be evaluated only with tests. Student observation forms, project and research assignments were also taken into consideration when making the evaluation. In this program, the use of various tools such as self- and peer-assessment, observation form was mentioned and sample forms were included (Ministry of National Education [MoNE], 2000). Therefore, it can be stated that the use of alternative assessment and evaluation tools is emphasized in addition to the use of traditional assessment and evaluation tools.

2005 Science and Technology Curriculum

The program has been prepared by taking into account the programs of countries such as the USA, Singapore, Ireland, Canada and the new developments in science education in the world. In the program, the name of the course was changed to "Science and Technology". The vision of the program is determined as raising all students as science and technology literate regardless of their individual differences. The spiral programming approach is taken into account in the program. In short, the subjects are given in a gradually expanding and deepening structure at each grade level, from the fourth to the eighth grade. The learning domains in this program are presented in Table 1 (MoNE 2005a, MoNE 2005b).

Table 1. 2005 Science and Technology Course Teaching Program

Learning Domains			
Knowledge	Skill	Attitude and Values	Science-Technology-Society-Environment (STSE)
Living Things and Life	Scientific Process Skills		Nature of Science Technology
Physical Phenomena			Relation Between Science and Technology
Matter and Change			Social and Environmental Context of Science and Technology
Earth and Universe			

When Table 1 is examined, it can be seen that the learning domains in the program are grouped under four main headings. These are: Subject Content (Living Things and Life, Physical Phenomena, Matter and Change, Earth and Universe), Skill Learning Domain (Scientific Process Skills), Attitude and Values, Science-Technology-Society-Environment (STSE). The subject content is oriented towards the acquisition of learning domain knowledge and expresses the basic subjects in science. Scientific Process Skills, Science-Technology-Society-Environmental gains, Attitude and Values, which are related to almost all science and technology subjects, are distributed in all units (Erduran Avcı & Önal, 2013). Emphasis was placed on teaching the subjects in this program by associating them with other disciplines. These associations are in the mode of in-class associations, associations with other lessons, Kemalism topics and connections with intermediate disciplines. While making in-class associations, the subject being taught was given by associating it with previous science subjects. While making associations with other courses, the subject was taught by associating it with disciplines such as mathematics and visual arts. While making associations with the subjects of Kemalism, the subject was tried to be associated with Atatürk's principles, reforms and thoughts. While making an associating with interdisciplinary disciplines, the subject was taught by way of associations with related interdisciplinary subjects such as “Disaster Protection and Safe Life”, “Human Rights and Citizenship”, “Entrepreneurship”, “Special Education”, “Sports Culture and Olympic Education”, “Health Culture”, “Guidance and Psychological Counseling” and "Career Consciousness" (Çil, 2020). Constructivist learning theory was adopted in this program. In measurement-evaluation, a performance-based measurement-evaluation approach has been adopted. The most striking aspect of this program is the strong emphasis on misconceptions. As an example, while some acquisitions were given, teachers were warned about possible misconceptions that might occur in students. With this program, teacher's guidebooks that will guide teachers in the learning-teaching process, and student textbooks and workbooks, that will help students, have been prepared. In the teacher's guidebooks, united annual plans, lesson plans prepared according to the 5E learning model, and all kinds of information and activity examples that teachers may need while teaching are included. Student textbooks, on the other hand, are prepared as the main source that students can benefit from while studying, and workbooks are prepared as a supplementary book with more activities. These are expressed as the strengths of the program. However, it was emphasized that the program has weaknesses as well as strengths. Some of these are as follows (Çil, 2020):

- The subject headings and student acquisitions in the program are quite high. Accordingly, it's an intense program.
- Although the understanding of constructivism is at the forefront in the program, when the program book, teacher's guide and student textbooks are examined, it is seen that the constructivist learning theory does not overlap with the philosophy.
- Although learning domains are provided under four main headings in the program, it has been observed that most of the acquisitions are in the domain of

cognitive learning, and very few acquisitions are related to the domain of attitude and values learning.

- Despite the emphasis on performance-based assessment and evaluation in the program, this understanding has not been reflected in practice.

2013 Science Course Curriculum

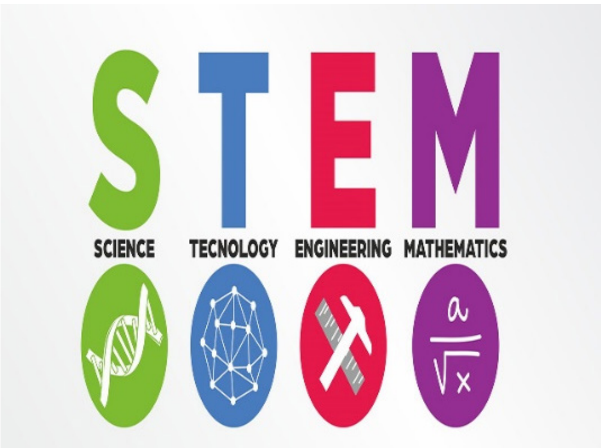
The program has been amended due to the aforementioned weaknesses of the 2005 program and the implementation of twelve years of compulsory education instead of eight years of uninterrupted and compulsory basic education since the 2012-2013 academic year. In this program, the name of the course was changed to "Science". This course has been taught since the third grade. Science courses were taught three hours a week in primary schools and four hours a week in secondary schools. Since the word technology in the 2005 program was removed in this program, the aims and objectives of the program have also changed. For example, instead of science and technology literacy, the term science literacy was used in this program and technology was expressed as a sub-dimension within science literacy. Instead of the constructivist theory view expressed in the 2000 and 2005 curriculum, a learning strategy based on research-inquiry philosophy has been implemented in this program. Thus, the guiding role of teachers has become more important and students are allowed to learn cooperatively in the learning process (Ayvacı, Er Nas, & Kirman Bilgin, 2020b). In addition, changes were made in the measurement and evaluation dimension and importance was given to the use of alternative measurement and evaluation techniques besides traditional measurement and evaluation techniques. In addition, emphasis was placed on self- and peer-assessment. In this program, the teacher's guide book and the student workbook were removed, and only the student's textbook was taught. The learning domains in this program are as given in Table 2 (MoNE, 2013).

Table 2. 2013 Science Course Curriculum

Learning Domains				
Knowledge		Skill	Affective	Science-Technology-Society-Environment
Living Things and Life	Scientific Process Skills	Life Skills	Attitude	Socio-Scientific Issues
Matter and Change		Analytical Thinking	Motivation	Nature of Science
Physical Phenomena		Decision Making	Value	Relation of Scienceand Technology
Earth and Universe		Creativity	Responsibility	Social Contribution of Science
		Entrepreneurship		Sustainable Development Awareness
		Communication and Team Work		Science and Career Awareness

It is observed when the learning domains of the 2013 science curriculum are examined that the knowledge learning domain consists of the subjects "Living Things and Life", "Physical Phenomena", "Matter and Change" and "Earth and the Universe"; skill learning domain consists of scientific process skills and life skills (creativity, decision making, analytical thinking, communication and teamwork, entrepreneurship); affective domain consists of motivation, attitude, value and responsibility; whereas the Science-Technology-Society-Environment learning domain consists of socio-scientific issues, sustainable development awareness, science and career awareness, relation of science and technology, the nature of science and the social contribution of science. Unlike the 2005 program, life skills have been added to the skill learning domain in this program, and the "attitude and value learning domain" was expressed as the "affective learning domain", while motivation and responsibility have also been included. Sustainable development awareness and socio-scientific issues were added to the science-technology-society-environment learning domain. "Career awareness" provided as an intermediate discipline in the 2005 program was included in the domain of science, technology, society and environment learning in this program. The "nature of technology" that was part of the domain of science, technology, society and environment learning in the 2005 program has been excluded from this learning domain in this program. While the strategies, methods and techniques to be given based on the theory of constructivism in the 2005 program are clearly stated in the program book, the learning theory of constructivism is not explicitly mentioned in this program whereas research-inquiry-based education is mentioned (Çil, 2020). The process of explanation and argument formation is also present in the research-inquiry process in addition to experimentation and discovery. In short, the application of the argumentation method has received significant importance in this program. Thus, the student will be able to express his/her thoughts comfortably, support them through different justifications, and create arguments against the claims of his/her peers (Eskicumalı, Demirtaş, Gür Erdoğan, & Arslan, 2014).

2017 Science Curriculum



Updating the 2013 science curriculum has become a necessity in 2017. One of the most important reasons for this situation is the inclusion of Science, Technology, Engineering and Mathematics (STEM) education to science education in the USA in 2001 (Zollman, 2012). Therefore, the most radical change made in the program is the inclusion of science, technology, engineering and mathematics understanding into the program. With this education, called STEM, it is aimed to enrich the physical, cultural and intellectual worlds of students and to develop their skills such as problem solving and critical thinking (Çorlu & Aydın, 2016). Thus, along with STEM education, the student will acquire 21st century skills such as problem solving, creativity, cooperation and critical thinking (Özkan & Okur Akçay, 2021). Therefore, in order for the STEM teaching approach to be effective and efficient, students must be problem-solving, logical thinkers, innovative, creative, technology literate and self-confident (Morrison, 2006). In this context, the vision of this program was determined as raising science literate individuals (MoNE, 2017). However, the preparation and publication phase of this program differed from the teaching programs implemented so far. Namely, before this program was put into practice, it was published as a draft curriculum on the official website of the Ministry of National Education, making it accessible to the opinions and suggestions of the public and stakeholders, which was then put into effect in the 5th and 9th grades during the 2017-2018 academic year (Özcan & Duzcanoglu, 2017). The learning domains in this program are as presented in Table 3.

Tablo 3. 2017 Science Course Curriculum Learning Domains

Learning Domains					
Knowledge		Skill		Affective	Science, Engineering, Technology, Society, Environment
Earth and Universe	Scientific Process Skills	Life Skills	Engineering and Design Skills	Attitude	Socio-Scientific Issues
Living Things and Life		Analytical Thinking	Innovative Thinking	Motivation	Nature of Science
Physical Phenomena		Decision making		Responsibility	Science, Engineering and Technology Relations
Matter and Its nature		Creativity		Value	Relation of Science and Technology with Society
Science and Engineering Applications		Entrepreneurship		Universal Values	Sustainable Development Awareness
		Communication and Team Work		National Cultural values	Science and Career Awareness
				Scientific Ethics	

Table 3 shows that the 2017 science curriculum has some differences compared to the 2013 science curriculum. For example; “Science and Engineering Applications” unit has been added to the knowledge learning domain. This unit constituted the last unit of grades four, five, six, seven and eight. Scientific process skills and life skills as well as engineering and design skills (innovative thinking) have been added to the skill learning domain. Values are given importance in this program. Scientific ethics, universal and national cultural values have been emphasized. However, unlike the 2013 program, engineering was added to the fourth learning domain and this learning domain was expressed as "Science Engineering Technology Society Environment".

2018 Science Course Curriculum

This program was created by updating the science curriculum prepared in 2017. One of the most fundamental changes made in this program was renaming the "Science and Engineering Applications" in 2017 as "Science, Engineering and Entrepreneurship Applications". In other words, the development of entrepreneurship skills was given importance in this program. In this respect, "Science and Engineering Applications" included as the last unit in the 2017 program was not presented as a separate unit and instead was included as part of the "Science, Engineering and Entrepreneurship Applications" integrated to science subjects. Science, Engineering and Entrepreneurship Applications sub-learning domain includes the scientific processes such as defining a problem from daily life related to the topics in the units, choosing the appropriate alternative solution for this problem, planning and experimenting with the chosen solution, collecting quantitative and qualitative data, recording observations, presenting the product and presenting it with graphics or reading skills, and providing different strategies to market the product (MoNE, 2018). Therefore, in this program, students are expected to develop a product/products to meet a social need regarding the concepts they have learned within the scope of science, engineering and entrepreneurship practices, and to present these products at science festivals at the end of the semester (Deveci, 2018). However it was observed when the units and subject domains were examined that even though the subject domain of "Earth and the Universe" was ranked last in the 2013 curriculum, it was ranked first for all grade levels in the 2018 curriculum. In addition, one of the most important changes made in this program was the addition of innovative thinking skills under the title of "Engineering and Design Skills", which was added to the skill learning domain. Therefore, the most emphasized concepts in this program are the concepts of "engineering", "entrepreneurship" and "innovation", which are the requirements of the age we live in (Deveci, 2018).

Skills Included in the 2017 Science Curriculum

The skill learning domain in this program consists of "Scientific Process Skills", "Life Skills" and "Engineering and Design Skills".

Scientific Process Skills

Scientific process skills are expressed as basic skills that make the individual active in science, help them learn, and ensure that the acquired knowledge is permanent while providing methods for research processes in which the individual is responsible for his/her own learning (Çepni, Ayas, Johnson, & Turgut, 1997). In the current program, these skills are presented as skills that scientists use while working (observing, classifying, measuring, recording data, creating a model by using data, making hypotheses, experimenting, changing and controlling variables) (MoNE, 2018). It can be stated when these skills are examined that they are frequently used not only in learning-teaching environments, but also in solving problems encountered in daily life.

Life Skills (21st Century Skills)

In the 21st century, in which technological, economic and social developments are experienced intensely, importance is given to raising individuals who will contribute to these developments. In this respect, these individuals are required to have skills such as critical thinking, problem solving, creativity, risk taking, initiative and decision making (Gordon et al., 2009). These skills are expressed as life skills (World Health Organization, 1999) or 21st century skills (Trilling & Fadel, 2009). 21st century skills can be defined as the knowledge and high-level skills that individuals must have in order to adapt to the 21st century, which is called the age of science and technology (Dede, 2010). These skills were added to the science curriculum as of 2013. In the current science curriculum, these skills are expressed as decision making, analytical thinking, creativity, communication and teamwork, and entrepreneurship (MoNE, 2018). While decision making, analytical and creative thinking skills are included in problem solving skills; communication, teamwork and entrepreneurship skills are the skills necessary for people to exist in societies (Ayvacı, Er Nas, & Kirman Bilgin, 2020a).

Analytical thinking skills comprise the process of reaching a conclusion by performing operations such as comparing, classifying, and error analysis after collecting data about a problem, organizing and distinguishing data (Marzano & Kendall, 2007). Entrepreneurship skill, on the other hand, can be defined as revealing the needs of the society and contributing to the economy by turning these needs into business opportunities (Habila-Nuhu & Pahalson, 2014). Communication and teamwork skills are among the social skills and form the basis of life skills (Redecker & Punie, 2013). Decision-making skill is the selection of the most appropriate solution among many solutions for a problem (Grace, 2009). Creative thinking skill is the ability of individuals to develop new solutions to new problems by using their existing knowledge and to produce new products (Beers, 2011).

Engineering and Design Skills

These skills in the curriculum are expressed as skills that enable students to create products using their existing knowledge and skills and develop strategies on how to add value to these products by integrating science, technology, mathematics and engineering disciplines thus taking students up to the level of innovation and invention with an interdisciplinary approach to problems (MoNE, 2018). Engineering and design skills include “engineering skills”, “problem solving skills”, “reasoning skills”, “association skills”, “innovative thinking skills”, “communication and cooperation”, “life and career skills” and “creativity” (Ayvacı, Er Nas, Kirman Bilgin, & 2020a).

Considering these skills, reasoning skills are those that an individual must have in order to make inferences based on logic. Since engineering design-based activities are based around a problem, the individual must have problem-solving skills to solve this problem (English, King, & Smeed, 2017). Regarding the ability for association, the individual must have the ability to establish connections between the domains of science, engineering, technology and mathematics, both with each other and between disciplines. In engineering skill, the individual first makes a preliminary design for the solution of the problem. In this process, she/he creates a presentation with her/his drawings or models. Afterwards, the product development process ensues with the selected and supplied materials and continuous testing is conducted. Depending on the testing process, the product is developed or modified. Only an individual with innovative thinking skills can create an idea, process or product design. Because the important aspect of innovation is being able to put forth original thoughts by assimilating ideas. Creativity, which can be defined as different or original thinking and generating ideas, is the most frequently applied skill among engineering design-based applications. An individual who has communication and cooperation skills can express her/his thoughts with different methods and techniques, benefit from information and communication technologies, and work together with people who have different ideas. Engineering design-based applications also affect life and career skills. These skills will contribute to the lives of individuals by enabling them to gain the knowledge and skills that will affect their future professional lives and also to plan both their daily lives and their future careers (Ayvacı, Er Nas, Kirman Bilgin, & 2020a).

Changes and Developments in the Education of Science Teachers

The teacher training programs, which were restructured in 1997 and put into practice from the 1998-1999 academic year, were updated again in the 2006-2007 academic year (Higher Education Council [HEC], 2007). It was observed when the science teacher training program was examined from among these updated programs that the weight of the domain courses have remained approximately the same, and that the School Experience I and Introduction to the Teaching Profession courses have been removed from the first year. The last change in teacher training programs was made by HEC in 2018. It can be seen when the science teaching undergraduate program in the new program is examined that there is a decrease in the content of the domain courses, while the choice and number of elective courses have been increased (HEC, 2018). However, it was concluded that the theoretical courses in the domain education have been reduced while the practices remained the same, that there was no change in theory and practice in the general culture courses, and that the vocational knowledge courses increased in theory over time, but decreased in practice (Ergun, 2020).

In 2008, the science and technology teacher special domain competencies were defined for the first time by the Ministry of National Education as five main competencies (planning and organizing the learning and teaching process, providing professional development, scientific, technological and social development, cooperation between school-family and society, monitoring and evaluation of development) and expressed as 24 sub-competencies within the scope of these five main competences (MoNE, 2008). However, it can be considered when these special domain competencies were examined that they do not overlap with current teacher competencies and do not meet the contemporary needs since they refer to the previous curriculum. Namely, in the current (2018) science curriculum, the skills that are desired to be acquired by the students in the Turkey Qualifications Framework are communication in native language and foreign language, digital competence, mathematical competence and basic competences in science-technology, social and civic competences, learning to learn, cultural awareness and expression, taking initiative and entrepreneurship. However, apart from these skills, the program also requires students to have the ability to use technology, entrepreneurship skills, and engineering-design skills (MoNE, 2018). Therefore, it is thought that science teachers who want to teach these skills to their students should first have these competencies, but science and technology specific domain competencies are not at a level to meet these requirements (Ergun, 2020).

CONCLUSION

The importance of raising individuals who will keep up with this century, that is, who will have 21st century skills, has increased in the 21st century in which scientific and technological developments are experienced very rapidly. Changes in the characteristics of the individual have also affected the understanding of science teaching, thus the science curriculum, and accordingly the education of science teachers who will train students with 21st century skills. In this respect, it can be said that there are some common features when science teaching programs from 2005 to the present are examined. It can be mentioned that these programs have a vision of raising science literate individuals, with the aim of teaching the four basic learning domains as knowledge, skills, affective and science-technology-society-environment; giving emphasis to the importance of concept teaching, adopting constructivist learning theory in the learning-teaching process; and giving importance to performance-based assessment and evaluation. However, regarding the constructivist approach in the 2005 Science program, and the inquiry-based approach in 2013 and 2018 science curricula, it can be said that student-centered approach is dominant in science curricula. In addition, there are some differences. As an example, it was observed that the 2005 and 2013 science curricula consist of four sub-learning domains: "Living Things and Life", "Physical Phenomena", "Matter and Change" and "Earth and Universe", and these units were taught in the same order in both programs. On the other hand, it is seen that the current (2018) Science curriculum consists of five learning domains: "Earth and Universe", "Living Things and Life", "Physical Phenomena", "Matter and Nature" and "Science, Engineering and Entrepreneurship Practices". On the other hand, while the "Living Things and Life" learning domain was handled in the first place in the 2005 and 2013 science curricula, it was observed that the "Earth and the Universe" learning domain was the first in the 2018 science curriculum. However, the learning domain, which was "Matter and Change" in other programs (2005 and 2013), changed to "Matter and Nature" in the current program (2018). The most important change made in the domain of knowledge learning in the 2018 science curriculum is the addition of the "Science, Engineering and Entrepreneurship Applications" sub-learning domain to this domain. By virtue of these applications, it is aimed that students make engineering applications related to science units, produce products and exhibit these products in science fairs, project exhibitions or science festivals. When the skill learning domains of these programs are examined, it is observed that only one single learning domain is given place in the technology program in 2005 which is scientific process skills; in the 2013 science curriculum, two learning domains, scientific process skills and life skills, were included, and in the current program in addition to these engineering and design skills added on the sub-learning domains. It is seen that the sub-learning domain of skills has been added. When the affective learning domains of the programs are observed and when the 2005 and 2013 science curriculums are compared, it is seen that the number of affective sub-learning domains has been increased, that is, the scope has been expanded. However, it is also seen that the affective learning domain has not been included as a separate title in the current science curriculum, and that these sub-learning domains have been mentioned in the special objectives of the curriculum. It can be put forth when the Science-Technology-Society-Environment (STSE) sub-learning domains of the programs were examined that this learning domain is the learning domain that has undergone the most changes over the years. It can be indicated that the 2013 science curriculum is the program with the most advanced scope in terms of the dimensions in which the STSE learning domain was developed and added. It is seen that STSE is not included as a learning domain in the current science curriculum, but it is only mentioned superficially in the special aims of the program. In addition, the current science curriculum has emphasized the inquiry-based learning approach with an interdisciplinary perspective. However, it can be said that the emphasis between disciplines is very superficial, that is, the absence of an expression that puts the STEM approach forward in the current (2018) science curriculum, is one of the important shortcomings of the current curriculum. Even though there is an emphasis on bringing together four important disciplines such as science, engineering, mathematics and technology in STEM education, it is seen that the new program emphasizes the concepts of science, engineering and entrepreneurship, but not sufficiently emphasizing the technology and mathematics disciplines. Besides this, the reduction of theoretical courses in domain education in the current (2018) science teaching undergraduate program, may make us encounter difficulties in raising students having skills for the 21st century as the special domain sufficiency of the science and technology teachers determined by the Ministry of Education might be insufficient in the frame of the Turkey Capabilities Frame for meeting the skills that are expected to be acquired by the students.

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