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# An Analysis of Science Curriculum Within the Context of Engineering and Design Skills in Turkey

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## Abstract

*Countries include the implementations of many methods and strategies to provide effective science education. For this purpose, changes are made in the curriculum within the process. The constructivist approach has influenced science curriculum since the beginning of the 2000s. Constructivism is based on active learning and meaningful learning, and it is important in constructivism to establish a relationship between the subjects learned and daily life. The development of advanced technology is progressing rapidly with each passing day. In addition to the advancement of technology, science and technology become more important. Thus, it is an important condition to teach the relationship between science and technology in science curriculum. Moreover, it is extremely important that the applications of science, technology, engineering, and mathematics (STEM) must be projected in curricula. STEM applications were especially included in science curriculum in Turkey in 2018. This study will include explanations about the engineering and design skills that are elaborated in science curriculum are and how to acquire these skills.*
**Keywords:** *STEM Applications, Science Education, Science Curriculum, Engineering and Design Skills*

## 1.INTRODUCTION

With the developing technology and scientific applications, a lot of scientific knowledge is obtained, and the applications of various methods are adopted with the intention of having students acquire this scientific knowledge. For this purpose, countries implement different curricula within the process to reflect these new methods and techniques with the philosophy of their own curricula. The performances of the countries in the international assessments (PISA, TIMSS etc.) are effective in the changes made in the curricula. It can be said that the low performance of the students, especially in these international assessments, is effective in changing the curriculum in Turkey.

In general, curriculum development studies are approached holistically and performed including all-course levels. The changes made in the curricula also manifest themselves in the science curricula implemented in Turkey. The purpose of teaching science to students is to raise individuals who do research, question, and make sense of the events around them.

Considering the vision of the science and technology curriculum, which has been implemented in Turkey since 2005 and included constructivism as its basic philosophy, the aim of the curriculum is to "raise all individuals as science and technology literate" (MEB, 2005). In the later period, although minor changes were made in the names and practices of science curricula, the basic philosophy was based on constructivism.

The change in science curriculum in Turkey continued with the revision made in 2013. With this curriculum, the name of the course changed and became "Science Course" and this curriculum was implemented from the 3$^{rd}$ grade of primary school to the 8$^{th}$ grade of secondary school (MEB, 2013). As a result of the integration of technology more into the daily life, there was a transition to a science curriculum in which science and technological applications were at the forefront. The science curriculum currently applied in Turkey is the curriculum prepared in 2018 (MEB, 2018).

### Constructivism and Science Education

It is seen that many learning theories have been developed for the actualization of meaningful learning. Considering the common points of learning theories, what comes to the forefront is to enable people to learn knowledge better, to reveal the relations between the learned knowledge and to carry out its continuity. In order to reach the desired opinion, application-oriented methods are developed, so it is seen that different methods are implemented.

It has been considered until recently that the knowledge that exists within the teacher's mind could be transmitted to the student as it was. This is the idea that lays the foundation of the methods put forward and applied. Therefore, the concepts of learning and teaching should be considered as different concepts.

It is important to reveal what the person knows. Thus, the idea of constructivist approach emerges here. In the constructivist approach, it is emphasized that knowledge is constructed in the mind of the person himself (Bodner, 1986). An important and necessary problem in the education process is how to construct and evaluate knowledge. Hence, it is thought that there is some correspondence between language and reality, there exists a logical coherence between observations and propositions, and that there is a reliable and systematic methods of testing our observations (Matthews, 2003).

In constructivism, students' prior knowledge is of great importance because students build new knowledge upon the foundation of previous knowledge. In this respect, it is important that students' prior knowledge should be determined, possible conceptual misconceptions should be revealed and thus teaching should be shaped accordingly. It is known that various teaching practices based on the constructivist approach are included in teaching environments. Learning circle, 5E, 7E learning models, inquiry-based teaching practices are some of these practices based on the constructivist approach. The basic approach of the Science Curriculum in existing practice in Turkey is constructed on inquiry-based learning.

**Inquiry-based Learning and STEM Practices**

The applications of various teaching methods and techniques are included in the learning environment to allow students to learn better. One of them is inquiry-based teaching activities. Humans are constantly in a questioning process throughout their lifespans, from conception to death. In the teaching process, memorizing facts and knowledge is not what is desired. The important thing is to construct the acquired knowledge well and to promote meaningful learning. It is stated that inquiry will help students to gain more in-depth knowledge about the subjects, to construct their knowledge in a more accessible, transmittable, and applicable way, and to obtain new knowledge with less effort (Ismail and Elias, 2006).

The rapid developments in the industrial revolution made technological development and digitalization even more effective. In this process, it is of great importance for students to adapt to technological applications. In this respect, students are expected to have critical thinking skills. With critical thinking, students want to learn, see the knowledge from many perspectives, become sceptical, analyse, and make logical decisions. Thus, curricula should have a holistic perspective. In addition to critical thinking skills, science, technology, engineering, and mathematics applications should be linked together and thus they must be discussed together. STEM is the integration of science (S), technology (T), engineering (M), and mathematics (M) which relates to both workforce and daily life experiences. STEM education is important because people may encounter many different problems throughout their lives (Hafni et al., 2020). STEM education contributes to the development of social, cognitive, and psychomotor aspects of the individual. With this training, the individual gains skills such as learning and questioning, problem solving, observation, experimentation, and presentation (West, 2012; as cited in Gülen, 2019). Within this context, it becomes important for individuals to have engineering and design skills while actualizing science education. Considering the study carried out by Harman and Yenikalaycı (2021), the views of pre-service science teachers on the activities related to the engineering design process in STEM education were examined. Eight pre-service teachers participated in the study conducted with case study. The activities performed were developed according to the following stages: identify the engineering design process, research, imagine, plan and create, test and improve, and communicate. It was revealed in the research that pre-service teachers stated positive opinions. Özer and Canbazoğlu Bilici (2021) in their study examined the effects of engineering design-based Algodoo activities on the 6$^{th}$ grade students' design skills, academic achievements, and learning retention. The change in their design skills were revealed with the rubric developed for evaluating engineering design process. As a result of the research, it was stated that the study made positive contributions to the development of skills related to the stages of the engineering design process including identifying the problem or need, developing a possible solution, building the prototype, testing and evaluating the solutions, and presenting the solution. In the study of Bakırcı and Kaplan (2021), semi-structured interviews were carried out with 10 teachers who actively teach science course. Their opinions on the engineering and design skills were involved in the current practice.

As can be seen from the studies conducted, it is important to include engineering and design skills in curricula. The aim is to develop these skills. In the next section, the purpose of the research is given.

## 2.PURPOSE OF THE RESEARCH

The study examined the science curriculum, which was put into practice in Turkey in 2018, in terms of content within the context of engineering and design skills. The philosophy of the curriculum which examined according to the theoretical foundations was explained and the reflection of this philosophy on learning outcomes was discussed at class levels.

## 3.FINDINGS

### 1) Findings Related to the Philosophy of Science Curricula

It is regarded that a holistic perspective is adopted in the science curriculum. Students actively participate in the teaching environment, and it can be stated that strategies based on inquiry and knowledge transfer are adopted. In the process, students look at problems from an interdisciplinary approach and the learned subjects are integrated with science, mathematics, technology, and engineering applications. Thus, this philosophy aims at contributing to students' high-order thinking, product development, invention, and innovation skills (MEB, 2018).

The learning process includes exploring, questioning, making arguments, and designing products. It also involves a lot of argumentation-based teaching activities. In addition, the quality of science that produces inputs for applications and economy was adopted. In this regard, activities that produce technologies to meet daily needs are included in the subjects in each unit (MEB, 2018).

### 2) Findings for the Analysis of Science Curriculum in terms of Engineering and Design Skills

The 2018 science curriculum was examined in terms of units and outcomes from the 5$^{th}$ to the 8$^{th}$ grade. However, only the units of the curriculum for the 5$^{th}$ and 6$^{th}$ grades and their outcomes are included in Table 1 (MEB, 2018).

**Table 1: Learning Outcomes Related to the Engineering and Design Skills in the 2018 Science Curriculum (5$^{th}$ and 6$^{th}$ grades)**

| **Names of 5$^{th}$ Grade Units** | **Outcomes for the Development of Engineering and Design Skills** | **A Total Number of Skills** |
|---|---|---|
| The Sun, The Earth, and The Moon | -F.5.1.1.2. Prepares a model to compare the size of the Sun with the size of the Earth.<br>-F.5.1.4.1. Prepares a model that represents the relative motions of the Sun, Earth, and Moon. | 2 |
| The World of Living Beings | | |
| Measurement of Force and Friction | -F.5.3.1.2. Designs a model of dynamometer using simple tools.<br>-F.5.3.2.3. Generates new ideas to increase or reduce friction in daily life. | 1 |
| Matter and Change | -F.5.4.3.2. Interprets the results by doing experiments on heat exchange by mixing liquids with different temperatures.<br>-F.5.4.4.2. Relates examples from daily life to expansion and contraction phenomena | 2 |
| Light Emission | -F.5.5.4.2. Explores the variables that affect the full shade by experience. | 2 |
| Humans and Environment | -F.5.6.2.2. Offers suggestions for the solutions of an environmental problem in his/her immediate surroundings or in our country.<br>F.5.6.2.3. Makes inferences for the environmental problems that will occur in the future due to human activities. | 2 |
| Elements of Electric circuit | -F.5.7.1.2. Make a diagram of the electric circuit that he has drawn | 1 |

| **Names of 6$^{h}$ Grade Units** | **Outcomes for the Development of Engineering and Design Skills** | **A Total Number of Skills** |
|---|---|---|
| Solar Systems and Eclipses | -F.6.1.1.2. Creates a model by ranking the planets in the solar system according to their proximity to the Sun.<br>-F.6.1.2.3. Creates a model representing the Solar and Lunar eclipses. | 2 |

| | | |
|---|---|---|
| Systems in Our Body | -F.6.2.2.1. Explains the functions of the structures and organs that make up the digestive system with models.<br>-F.6.2.3.1. Explains the functions of the structures and organs that make up the circulatory system with models.<br>-F.6.2.3.5. Evaluates the importance of blood donation regarding the society<br>F.6.2.4.1. Explains the functions of the structures and organs that make up the respiratory system with models.<br>-F.6.2.5.1. Summarizes the functions of the structures and organs that make up the excretory system by showing on the models. | 6 |
| Force and Motion | -F.6.3.2.2. Shows the relationship between distance, speed, and acceleration on a graph. | 1 |
| Matter and Heat | -F.6.4.2.2. Calculates the density of the various types of matters as a result of the experiments designed<br>-F.6.4.3.2. Determines the criteria for the selection of thermal insulation materials used in buildings.<br>-F.6.4.3.3. Develops alternative thermal insulation materials.<br>-F.6.4.3.4. Discusses the importance of thermal insulation in buildings in terms of family and country's economy and the effective use of the resources.<br>-F.6.4.4.2. Discusses the effects of different types of fuels used for heating purposes on humans and the environment.<br>-F.6.4.4.3. Researches and reports the precautions to be taken regarding poisoning from stove and natural gas. | 6 |
| Sound and its Properties | -F.6.5.4.2. Makes predictions to prevent the propagation of sound and tests predictions.<br>-F.6.5.4.4. Gives examples to acoustic practises.<br>-F.6.5.4.5. Designs a setting that will set an example for the propagation of sound and acoustic practices. | 3 |
| Systems in Our Body and Their Health | -F.6.6.1.1. Explains the nervous system and the functions of the central and peripheral nervous system on a model.<br>-F.6.6.1.4. Based on research data, discusses what should be done to be able to overcome adolescence period healthily.<br>-F.6.6.2.1. Explains the structures of sensory organs on a model.<br>-F.6.6.2.4. Discussed the precautions to be taken to protect the sensory organs' health. | 4 |
| Conduction of Electricity | -F.6.7.2.1. Predicts the variables which the brightness of a light bulb in an electrical circuit depends on and tests his/her predictions by experience. | 1 |

When the data in Table 1 is examined, it is seen that the outcomes related to the engineering and design skills in each unit are included.

## 4.RESULTS AND DISCUSSON

It is seen that the learning outcomes based on inquiry in the science curriculum include practices that make the students active and bring their exploratory skills to the forefront. The basic philosophy of the curriculum has already included the constructivist approach. Students are required to design, acquire life skills, and develop entrepreneurial skills in the curriculum in which STEM applications are integrated with the subject content. Students are supported by some state institutions (TÜBİTAK and etc.) to present their studies carried out under the guidance of their teachers throughout the year. Students present the materials they have prepared in the lessons at the science festivals that are requested to be held at the end of the semester. Thus, everyone becomes aware of the studies carried out at every grade level and social constructivism, a dimension of constructivism, is put into practice. In general, it can be stated that the science curriculum reflects the philosophy of constructivism and there are
sufficient outcomes in terms of engineering and design skills.

In addition, it will not be desirable if the practices remain in writing only in the curriculum. Therefore, the current situation can be analysed by taking the opinions of teachers and students in terms of schools and course teaching content. Thus, it can be stated that this will lead to the development of more effective and efficient studies.

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