

An Overview of The STEM Education Model

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Introduction

Today, knowledge is the most easily accessible reality. The acceleration of access to knowledge has changed the expectations of societies from individuals. The expectation of societies from individuals is to be able to offer creative solutions with the knowledge they have (Bağcı & Şahbaz, 2012). Today, it is more important to make knowledge useful than to have knowledge. This has increased the importance of interdisciplinary studies. The modern world approaches individuals with a holistic education approach that questions them and can transfer the knowledge they have to different fields (Şahin Alpaslan et al., 2014). Especially the developments in the field of artificial intelligence have increased the interaction of technology with other branches of science. The increasing interaction of technology with science, engineering and mathematics has increased the importance of the STEM approach. For example, when it is desired to design a drug with artificial intelligence, a mathematical infrastructure is needed for the theoretical modeling of the newly created drug, and a science and engineering infrastructure is needed for its synthesis. Technological developments and innovations in education systems increase the need for the STEM approach. There are countries that are trying to implement STEM education in order to provide students with the knowledge and skills needed in the 21st century and to cope with the challenges of the fourth industrial revolution (Bahrum et al., 2017; Brown-Martin, 2018; Sulaiman et al., 2023; Türk et al., 2018).

Success in education is defined as the display of appropriate behaviors in line with the goals of the determined program (Demirtaş & Güneş, 2002). Today, the goals of programs are generally to raise individuals with 21st century skills. When the STEM education model is successfully implemented, the cultural world of the student is enriched while achieving the determined goals, and at the same time, it develops self-efficacy such as problem solving and critical thinking (Corlu & Aydın, 2016).

Comparison of STEM education models in different countries

STEM is a term that was included in the policies of the US government in the early 90s. (Koehler et al., 2016). Since then, countries have tried to integrate the STEM education model into their education systems in order to increase their competitiveness. In particular, technological developments in China have pushed the US to seek new ways to increase its competitive power in this race. This has enabled STEM to enter education policies in the US. In the 2000s, other countries have added the STEM education model to their own policies because the STEM education model

includes features that individuals in the 21st century need to have, such as problem solving, creativity and collaboration. (Gough, 2015). Although countries have a consensus on the importance of STEM education, there are various differences in practices. In other words, countries determine their STEM education policies in line with their own needs. Accordingly, practices in STEM education vary. According to the study conducted by Arslan and Arastaman, (Arslan S. Y. & Arastaman G., 2021) STEM education in Australia is based on improving the health of the population, preserving the existence of water and food for future generations, growing the economy and increasing the power of the country. It is understood from the study of Arslan and Arastaman that the aim of STEM education for Hong Kong is to raise individuals with versatile and different skills that will increase the competitive power of the country. In the same study, it is understood that the aim of STEM education for Ireland is to raise individuals with high-quality labor force, and Canada wants to equip its citizens technologically and increase their competencies such as critical thinking and problem solving with STEM. America is the first place in the world where STEM education was introduced. In America, it is aimed to continue the vision of being a global leader with STEM education. According to the STEM education report published in Turkey in 2016 (MEB, 2016), while the aim in Russia was to develop science, engineering and medical programs with STEM, the aim in the Netherlands was to increase the number of scientists and engineers, in France to increase the interest of students with interdisciplinary projects, and in Croatia to create new opportunities, contribute to quality education and socioeconomic success. In the same report, Ireland planned STEM education as a common goal of the business world, government and all stakeholders, while Finland is one of the countries where STEM education is implemented most intensively compared to other countries. The same report mentions that steps have begun to be taken to make STEM education important for Turkey. In particular, the science centers that have been opened increase the curiosity of children and young people in science and technology. In this context, the science and art centers (Bilsem) in our country and the Deneyap workshops that have been opened in recent years can be seen as a result of the impact of the STEM education model on our education policies. As seen in the sample countries above, STEM education directs the education policies of countries with different purposes.

Characteristics of the STEM education model

Let's try to briefly define the STEM education model that will increase the competitiveness of countries in the 21st century. It would be appropriate to examine the STEM education model according to the study conducted by Akarsu and his colleagues (Akarsu et al., 2020). This study suggests that the STEM education model has the following ten features. The first feature is an interdisciplinary approach. The second feature is that it should be constructed with a context that has real-life social value. The third feature is that it should cover Engineering Design Processes. The fourth feature is that the decision-making process should be based on evidence. The fifth feature is that the design process should be iterative. The sixth feature is that cognitive processes in learning should be structured step by step. The seventh feature is that while learning, mistakes are made and lessons are learned from these mistakes. The eighth feature is that the process, not

the product, is important. The ninth feature is that there is no single solution, but multiple different solutions. The tenth feature is that it includes group work. Now let's take a look at these titles in a little more detail.

1- Interdisciplinary approach feature

STEM is formed by the first letters of the English meanings of the words Science, Technology, Engineering and Mathematics. The STEM education model has developed with the coming together of these four basic disciplines. Interdisciplinary interaction has increased a lot especially today. For example, when you want to develop a technological device, you primarily benefit from science fields such as Physics, Chemistry or Biology. You produce technology using engineering and mathematics infrastructures. When you want to produce a product, you benefit from each of the disciplines that give their name to the STEM education model. (Furner & Kumar, 2007).

2- The feature of being constructed with a context that has social value from real life

First of all, it is necessary to define what the concept of context is. According to Duranti and Godwin (Duranti & Goodwin, 1992) context is: 'a focal event embedded in its cultural environment.' Accordingly, designing a technological device that can kill bacteria to protect public health in the society one lives in is a context with social value. In order for the student to be able to make such a design, a correct construction or planning must be made.

3- Engineering Design Processes feature

Engineering design processes are an approach that inspires the STEM education model. In this approach, the systematic method of problem solving within the concept of engineering is explained (Moore et al., 2013, 2014). While Moore and his colleagues (Moore et al., 2013) summarized the engineering design processes as defining, learning, planning, trying and testing, English and King (English & King, 2015) summarized the engineering design processes as problem scope, idea generation, design, manufacturing, evaluation and redesign.

4- The decision-making process is evidence-based

STEM Engineering design experiences in STEM education help students connect science and mathematics knowledge as well as show connections between learning and the real world (Estapa & Tank, 2017). It follows an evidence-based path while making this connection (Crismond, 2001; Mehalik et al., 2008; Purzer et al., 2015).

5- The design process needs to be iterative

Mühendislik In the 2013 study of Moore and his colleagues (Moore et al., 2013) and in the 2015 study of English and King (English & King, 2015), it is understood that the design process is an iterative process and that the process is more important than the final

product for the STEM education model. In this process, it is seen from both studies that the design step is a step that is iterative and develops with the process.

6- The feature of step-by-step structuring of cognitive processes in learning

STEM In STEM education, cognitive behavioral gains should be planned correctly. Because STEM is an educational model that requires students to use high-level cognitive behaviors (Stohlmann et al., 2012). Therefore, the cognitive process should be carefully and correctly designed for STEM. In the literature review before STEM education, determinations regarding cognitive processes were generally made for one or two cognitive process steps (Türkkan, 2017).

7- The feature to make mistakes and learn from them

It has been stated in the literature that the process is important in the STEM education model and that the mistakes made in this process allow for different experiences to be gained. (English & King, 2015; Moore et al., 2013).

8- The feature that the process is important, not the product

In the STEM education model, the process required to reach the product is as important as the product. Because the rights and wrongs done until reaching the product are a step in the learning process. The student moves on to the next stage for everything he does right and finds the right thing by learning from the wrongs he does. Thus, he experiences many learning environments until reaching the product. It is known that the result is more important than the process in traditional education approaches. Therefore, instead of evaluations related to the process, studies on evaluations of the result are encountered in literature reviews (Dereli & Türkkan, 2005; Türkkan & Dereli, 2005).

9- There is not a single solution but multiple solutions

In a study on engineering design processes used in the STEM education model, Wang and colleagues (Wang et al., 2024) stated that one type of solution does not fit everyone due to different learning motivations. Having different solutions depending on the process and the student is a situation that can be seen in the STEM education model.

10- Group work

The importance of group work in the STEM education model has been emphasized in many studies (Moore et al., 2014; Thibaut et al., 2018). Group work in the STEM education model also supports peer education.

Conclusion

The 21st century skills that states want individuals to have in the future are almost provided by the ten features of STEM mentioned above. In this sense, states should give more place to the STEM education model in their education policies for the future. A state's ability to compete technologically

with other states in the world depends on well-educated human resources. Many states have started to implement the STEM education model in their own education systems. However, there is no unity in this application, that is, each state implements the STEM education model differently according to its own education policy and the human resources it needs. The STEM education model also includes engineering design processes due to its features. In this sense, Teknofest events held in Turkey increase the interest of young people in technology and engineering. Again, Science and art centers and Deneyap workshops opened in Turkey in recent years have increased the interest of children and young people in science and technology. Our country's bilsem and deneyap workshops have introduced young people and children to the STEM education model. However, these centers and workshops are not enough. In order for STEM education to spread more in Turkey, Science centers, Science and art centers and Deneyap workshops need to be brought together with more children and young people. In this way, a Türkiye that can produce technology and compete with other countries will be shaped.

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