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*Conceptual Article*

# Mathematics instruction from STEM education perspective: "The whole is more than the sum of the parts"

**Şahin Danişman**

*Department of Mathematics Education, Düzce University, Turkey*

Correspondence should be addressed to Şahin Danişman; sahindanisman@duzce.edu.tr

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This paper aims to put forth the importance of mathematics in STEM education and to put a point of view for mathematics instruction. The importance of mathematics for other STEM disciplines has been described after the STEM education; its components and its importance for 20th century have been discussed. In conclusion, mathematical modeling, problem- and project-based learning should be used during instruction to help our students have a creative thinking problem solving skills and teachers should have a wide perspective and skill to be able to integrate all these disciplines in their classrooms.

Keywords: STEM; Mathematics education; Integration

## 1. Introduction

Although most of the curriculums from various countries emphasize focusing on the real life problems, most of the courses/disciplines have been taught in isolation to solve these problems. Accordingly, most of these attempts result in handling the problems from just a perspective instead of a holistic one. Hence, STEM [Science, Technology, Engineering & Mathematics] education grabbed an important amount of attention from educational environments. Educators and policy makers from all around the world have an increasing concern for STEM education in the last decade. As years passing over, we have to adapt to rapidly evolving information and technology in this digital age, which may be possible through education in a meaningful and powerful education settings. The STEM education may be thought of vital in terms of its purposes: taking big steps in the industrialization of the countries, having the promise of the global market, providing economic advantage, educating qualified individuals who are component in the current and future generations of business, to name a few (Çevik & Özgünay, 2018).

Moore et al. (2014) defined integrated STEM education as "an effort to combine some or all of the four disciplines of science, technology, engineering, and mathematics into one class, unit, or lesson that is based on connections between the subjects and real-world problems" (p. 38). Bearing this definition in mind, it may be concluded that STEM education should include problem-based learning on the basis of real life contexts through cohesive teaching approaches rather than isolated ones. Stating that the stem can be grounded within the situated cognitive theory, Kelley and Knowles (2016) summarizes the foundation of this theory as focusing on the importance of how knowledge and skills can be applied as well as learning the knowledge and skills.

STEM helps us gain an understanding of teaching these disciplines together and intertwined rather than teaching them in an isolated way. To see and understand the differences between different approaches of integration, Vasquez et al. (2013) presented the integration of the disciplines with increasing levels, which means a more powerful interconnection among different disciplines in higher levels (see Table 1). This continuum from disciplinary to transdisciplinary for integration with increasing interdependence among the disciplines may help researchers and teachers get a better understanding of STEM integration.

Table 1.
Increasing levels of integration

| Form of integration | Features |
|---|---|
| 1. Disciplinary | Concepts and skills are learned separately in each discipline. |
| 2. Multidisciplinary | Concepts and skills are learned separately in each discipline but within a common theme. |
| 3. Interdisciplinary | Closely linked concepts and skills are learned from two or more disciplines with the aim of deepening knowledge and skills. |
| 4. Transdisciplinary | Knowledge and skills learned from two or more disciplines are applied to real-world problems and projects, thus helping to shape the learning experience. |

The first component of STEM is engineering which helps students focus on the activities with engineering perspective in mind. Including engineering into the activities may provide students a way of thinking with systematic approach to solve the problems they encounter in life. This discipline is also very close to other disciplines of STEM, as Purzer et al. (2015) states that engineering design and scientific inquiry are interwoven. Science helps students understand the real life and think in a way of scientists do. Scientists generally point out that most of the tools, technologies, medicines or other components we use in real life are the results of the scientific researches (Rull, 2014). This point also shows the interdependence of the engineering, technology and science. Especially, the link between the engineering and technology is expressed by the researchers (Barak, 2012). Hence, we may suggest teachers to teach in a way to improve scientific thinking and inquiry so that the students may be creative to be able to solve the problems and improve the conditions. Technology may be taken into consideration at this point, since it both helps science and engineering to go further and is a result of the scientific results. According to Herschbach (2009), technology can be viewed from two perspectives: engineering and humanistic views. The first view claims that technology should be thought as making the material objects, while the second view indicates the use of technology for human purpose. The relationship among these three disciplines is underlined with the mathematical thinking since it helps them to study and produce in all means. Since mathematical way of thinking is closely related with problem solving (Schoenfeld, 2000), students who are successful with mathematical thinking will be able to approach problems in a more productive way and use mathematical knowledge to develop the engineering, scientific and technological inquiries.

Thinking of mathematics education from STEM perspective requires us to think the relationship of mathematics with other disciplines during mathematics instruction as well as to teach mathematics with context based and meaningfully. Common Core Standards (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010) identifies mathematical standards for practice to solve mathematical problems. These standards can be summarized as:

- Make sense of the problem and persevere in solving them.
- Reason abstractly and quantitatively: to decontextualize - create abstractions of a situation
- Construct viable arguments and critique the reasoning of others.

- Model with Mathematics.
- Appropriate tools strategically.
- Attend to precision.
- Look for and make use of structure.
- Look for and express regularity in repeated reasoning.

When these standards taken into consideration, it can be said that mathematical modeling and teaching mathematics with problem and project-based approach is critical for mathematics education. Moreover, focusing on these standards may help teachers to create a successful teaching environment for integrated STEM education. Mathematics education should prepare students for applying mathematics in all sorts of work- and everyday-life situations (Gravemeijer, Stephan, Julie, Lin, & Ohtani, 2017).

Realist mathematics education which claims the instruction of mathematical knowledge in context-based environments and real life situations (Freudenthal, 1971) may also be thought of supportive for the STEM education. Accordingly, the students have chances to explore the mathematical knowledge themselves (Fauzan, 2002; Gravemeijer, 2010).

STEM may also be though in relevance with mathematical modeling which means transferring real life problems into mathematical world, solving the problem with mathematical objects and transferring the solution back to the real life so that the real life problem is solved through the mathematical processes (Cheng, 2001). Mathematical modeling helps students cope with the unusual situations and use flexible and creative thinking skills to solve the problems (English, 2006; Lesh & Doerr, 2003). Approaching the mathematical modeling from a different perspective, Stella and Warner (2018) provides a mathematical model design inspiring from the work of Carson and Cobelli (2001).

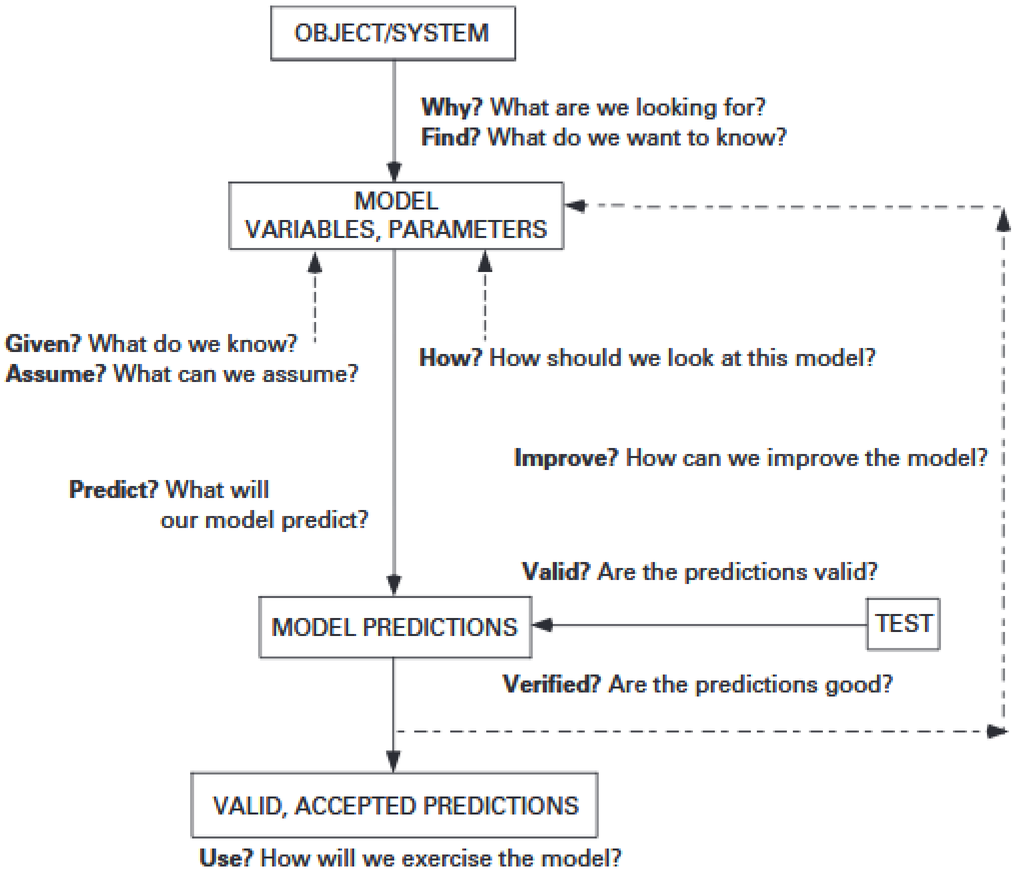


*Figure 1*. Mathematical modeling: How questions asked

This model may help us approach the problems from a different perspective and follow a systematic approach for the solution of the problems.

## 3. Conclusion and Recommendations

Research shows that critical thinking, problem solving, collaboration, agility and adaptability, initiative, effective communication, analyzing information, curiosity, imagination, etc. are so important in the century we live (Voogt & Pareja, 2010; Wagner, 2014). When integrated STEM education taken into consideration, we may claim that most of these skills may be improved through a successful integration of the disciplines with STEM based approach. Mathematical thinking is an underlying skill in improving these skills and STEM integration since all disciplines requires mathematical way of thinking. It is hoped that this commentary may help researchers and teachers to focus on the role of mathematics for STEM education to help students gain the required skills.

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