Standards Analysis

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The E in STEM: Meaningful Content for Engineering

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Engineering can be viewed as a unifying bridge between the various other disciplines defined by STEM: science, technology, and math. An examination of the standards for each discipline reveals a multitude of engineering connections. It is a valuable pursuit to analyze the similarities and differences between the crossovers of engineering with science, technology, and math.

Beginning with science, the Next Generation Science Standards (NGSS) contain an appendix dedicated to engineering design [2]. Further, one of the three dimensions of the NGSS is titled science and engineering practices (SEPs). In the NGSS Framework, there was a decision to broaden the definition of engineering. They delineate a shift from thinking of engineering as simply applied science to "any engagement in a systematic practice of design to achieve solutions to particular human problems," [2]. The SEPs are named as such to reflect the overlapping nature between science and engineering. For example, one SEP is constructing explanations and designing solutions, with the former referring to a scientific practice and the latter to an engineering mindset. A standard included within the seventh grade curriculum I teach is MS-PS1-6, which states: "Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes." Through this engineering-design-based standard, students come to understand the scientific principles of thermal energy transfer in chemical reactions. Not only do the NGSS incorporate engineering principles into the science standards, but they also establish separate engineering design standards. However, they do not go so far as to provide an entire set of engineering education standards, but rather express what engineering principles are required to prepare a scientifically-literate citizen.

With regards to the Common Core State Standards (CCSS) for Mathematics, engineering connections are not as deliberately portrayed within the standards document as they are for the NGSS [3]. While they are not made obvious within the standards document itself, there are many ways to integrate math and engineering. A great resource I've found is TeachEngineering[1]. This site allows users to view engineering lessons/units based on the CCSS Mathematics or English Language Arts standard of interest. For example, one of the mathematics practices defined by the CCSS is "make sense of problems and persevere in solving them" [3]. Interpreting this allows for interesting connections with engineering, because engineering truly revolves around problem-solving. TeachEngineering provides a unit titled "What Is A Computer Program?," in which students are introduced to the logic behind programming [1]. Through this unit, students must persevere as they create and test programs using LEGO robots. This overlapping skill of problem-solving applies to mathematics and engineering, as well as science and technology.

Lastly, the Standards for Technological and Engineering Literacy (STEL), present a direct relationship between technology and engineering, as these standards consistently have the two presented in unison. The STEL framework is broken into three dimensions: core disciplinary standards, technology and engineering practices, and technology and engineering contexts. One standard of which I am particularly fond is the following: "1L. Explain how technology and engineering are closely linked to creativity, which can result in both intended and unintended innovations" [4]. This standard aptly expresses the role creativity plays in the problem-solving process shared by the technology and engineering disciplines. In both engineering and technology practices, the performer has to be actively engaged in novel and adaptive thought.

So often, technology and engineering can become blurred together, with many not realizing the distinct role each plays within society. The engineering-design process can utilize technology, or even lead to the development of new technology/leveraging of technology in a new capacity. However, technology creation and use is not in and of itself engineering. Broadly, engineering might be considered the problem and the plan for solving it with technology being the solution or product.

Science, math, and technology all have a close relationship with engineering. This reflects that engineering design problem-solving is a mindset necessary for all STEM practices. The clearest distinction among the connections is that the standards documents for science and technology explicitly delineate the relationships with engineering, while the math document does not. The greatest common ground is the notion of problem-solving. In all STEM disciplines, it is necessary to practice and develop problem-solving skills. Creativity is the agreed-upon way we approach STEM in an quickly-evolving 21st century world, as reflected in the standards documents for K-12 education. Therefore, it is critical educators are trained in effectively integrating engineering practices, specifically those directed at problem-solving and creativity, in all STEM classes.

References:

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