What Is This Thing Called STEM?

By Jill Berkowicz and Ann Myers on June 11, 2015 6:12 AM | **1 Comment**

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With apologies to **Cole Porter**....
What is this thing called STEM?
This funny thing called STEM?
Just who can solve the mystery?

Pressure to increase reading and mathematics test scores continues to dominate the lives of educators and **deflect attention from science literacy**. One potential bright spot is increased national and local attention to an amorphous thing called STEM, short for science, technology, engineering and mathematics. Inclusion of engineering in the **Next Generations Science Standards** has provided an additional boost. But, what is meant by the term, STEM is in the eye of the beholder. For increased STEM attention to turn into improvement we need more clarity, resources, experimentation, research and above all patience.

With increased visibility, school and district leaders are increasingly seeking support to initiate "STEM" programs or "STEM" schools. Asking several questions is a good place to start.

- Which of the STEM disciplines we are already teaching, at what level of depth and through what instructional methodology?
- What do we want to do that is new?
- What is the expertise of our staff in each of the diciplines?

These are important questions because while all of districts already teach science and mathematics, they do so through widely disparate goals, instructional resources and methods. Classrooms vary with respect to whether they remain didactic and textbook driven or the extent to which they have embraced actively engaging students in the practices of science, engineering and mathematics. Instruction in technology and engineering varies from nonexistent to extensive. Access to and educational use of digital technologies is also highly divergent.

First some clarity about terms: Science is a body of knowledge about and a process to develop explanations of now the natural world works. Engineering is also a body of knowledge as well as a process of informed design of objects and processes to solve problems about living the world. Technology is the product of science and engineering- the physical and intellectual tools that help us navigate the natural and engineered worlds in which we live. Mathematics is the study of patterns and relationships among quantities, number and space. Without the computational, representation and analytic tools of mathematics progress in the STE of STEM would halt.

Much of the recent attention to STEM comes with an expectation of some degree of instructional interdisciplinarity. The impetus for this expectation draws upon powerful ideas related to cognition and development, interest and motivation, and emulation of the world of work. However, it is important to note that research about interdisciplinary STEM instruction is still developing. Clarity about the nature of each of the STEM disciplines and how practicing professionals interact with one another is necessary, but not sufficient to design STEM education. Some features of learning may emulate the investigative and creative work of professionals, but they are not identical. Students have yet to develop deep knowledge of disciplinary concepts and practices and are not as able to draw upon varied expertise as professionals. In addition, while "real-world" problems may be meaningful and engaging, they are often highly complex, making the orchestration of effective learning activities challenging.

Many school districts are now seeking guidance about how to navigate this complexity. Most have come to think of STEM as something more that the sum of its parts. In our work, we find several perspectives. Some are looking for support and guidance to develop educational connections across the disciplines. Most want to do so through some variation of active or project-based learning, often through engaging students in learning activities relevant to contemporary issues. Others find gaps in their curriculum, particularly with respect to engineering. There are several unifying notions across these requests: Learning is most effective when it is cognitively engaging, when students make connections across the traditional disciplines, and when their learning is personally or socially meaningful.

These are great starting points, but insufficient to move forward with direction and purpose. Let's start with clarity about goals. Education policy is the US is contested because we have disparate goals. However, a unifying starting point is defining the overarching goal of **preparing all students for life, work and citizenship**. As articulated in National Research Council's **Framework for K-12 Science**

preparing all students for life, work and citizenship. As articulated in National Research Council's **Framework for K-12 Science Education,** which requires engaging students to understand and learn the core ideas, cross cutting concepts and practices of scientists and engineers. It also requires doing so in ways that support the identity development and self-confidence of the full diverse range of learners.

These goals set the stage and maybe the actors, but do not describe the play. The good news is that multiple scripts are still being written and tested with multiple audiences. That is exactly the flexible thinking that is required for progress. The **National Academy of Engineering** and the **National Research Council** recognized the disparate and preliminary nature of ideas about STEM integration in K-12 Education in a **2014 publication** in a comprehensive review of research on integrated STEM. I will not reprise all of their findings and recommendations here. However, it is important to note that they found reason for promise, but also challenges to be addressed.

First, while interconnections are an important dimension of learning, without strong disciplinary knowledge and active engagement in disciplinary practices, linkages could prove to be impossible, fleeting or superficial. In addition, many so-called real world problems are extraordinarily complex, potentially overwhelming the cognitive capacities of developing learners.

Second, students do not automatically make interdisciplinary connections that may be implicitly obvious to adults. Instructional explicitness- which is different than telling- is crucial.

Third, because the developmental progression of learning is unique to each discipline, finding the sweet spot for accessible and meaningful interdisciplinary learning is challenging. For example, through systematic testing students might be able to select an optimal turbine shape for a wind-driven electric generator, but without understanding the underlying physics principles. Similarly, students may be able to select effective gear arrangements to propel a robot, but struggle with the proportional reasoning aspect of the mathematics of the force and motion relationships.

Fourth, interdisciplinary STEM teaching presents long-term professional growth challenges. Many disciplinary teachers have yet to develop experience and expertise with what may be an essential feature of effective interdisciplinary STEM instruction: teaching through engaging students in the STEM practices. In addition, most teachers learned their craft in single disciplines or in the case of elementary teachers have little formal STEM background knowledge.

To be clear, I am making a case for, not against an interdisciplinary STEM approach. Engaging interdisciplinary learning provides a strong motivational need to know context for students. Making progress on the promise of integrated STEM learning will require careful planning, experimenting with and testing and revising prototypical examples, extensive research, embracing what can be learned from failure and a great deal of patience. Teachers will need extensive opportunities for professional growth with colleagues and experts. They will need **guidance to select and develop instructional materials.** They will need additional resources and curricular examples and the time and, most important, risk free space to try approaches and activities for learning out multiple times, gain expertise, and then adapt them or reject them.

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