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# Editorial: Integrated STEM and Current Directions in the STEM Community

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Let's talk about real STEM activities; that is, those that *genuinely* integrate the use of science, technology, engineering, and mathematics. In late September 2017, a group of approximately 50 leaders – organization presidents, journal editors, faculty members, and technology developers – met to not only discuss technology, but to advance the dialogue about technology in STEM and other areas.

During this National Technology Leadership Summit (NTLS; see ntls.info), concurrent "strand" deliberations took place over 2 days. One of those strands was entitled *American Innovations in the Content Areas: STEM*, and the discussion within that strand is the focus of this editorial. The *American Innovations* project has students reconstruct and enhance early inventions using advanced manufacturing, while exploring related science and mathematical models. As a springboard for discussion, our group engaged in two project activities, one involved taking a series of measurements to derive Ohm's Law and the other demonstrated an activity that had middle school students derive Ampere's Law for Solenoids.

Here we outline the three main areas of the group's discussion, including (a) the benefits of integrated STEM activities, (b) difficulties of implementing integrated STEM activities in schools, and (c) action items to move forward as a STEM community. We encourage your comments and feedback to further this exchange.

First, what are the *potential benefits* of using integrated STEM activities and curricula? The NTLS strand group discussed several types of benefits, such as the following:

- Because an integrated STEM activity will usually have an authentic problem or project at the center, integrated STEM activities can be designed to have students experience, firsthand, the natural connections among the STEM content areas.
- While working on such projects, there are many opportunities for students to see the relevance of these content areas to their lives. Students can see why content knowledge in each of these subjects is useful and important.
- Solving an authentic nontrivial problem, designing a working product or prototype, or developing a mathematical model from collected data will be necessary to engage students in scientific and critical thinking.
- When students are engaged in developing real solutions and can connect their work to understanding or enhancing the world around them, they are empowered. Not only is their content knowledge and appreciation enriched, but they gain a voice, strong with scientific literacy, to make predictions, take a stand, and argue a position.

Second, we realize and acknowledge that there are *challenges and barriers* to implementing integrated STEM activities/curricula in traditional courses in typical school settings. These challenges and barriers include the following:

- Instructors often point to *time* as a main barrier to implementing new material, particularly when traditional school schedules are not conducive to project-based activities needing more time.
- Additionally, school subjects are often taught in silos. We heard that current curricula, often based on tradition, state standards, or national standards, are packed. Where is the space to do problem-based and project-based activities in the curricula?
- For some integrative STEM activities, new scientific or engineering equipment and supplies will be necessary (e.g., design software, 3D printer, laser cutter, meters).

- Additional content knowledge, sometimes outside of an instructor's focus or comfort zone, is required to implement integrated STEM activities well. How does a science teacher concentrate on mathematical models, or how does a mathematics teacher deliberate about science content needed for real-world connections? In particular, the NTLS group discussed engineering and its pivotal role in integrated STEM activities/curricula, yet we quickly noted that many mathematics and science teachers lack engineering and technical skills.

This leads us to the third topic of discussion. What *next steps* can be taken in order to have more widespread integrated STEM activities/curricula?

- As instructors we need a common vision of what could be and a common mindset of how to get there. We need cultural change in schools and with teacher education.
- Teacher buy-in about the importance and value of integrated STEM is key to this common vision and subsequent actions.
- Accessible information to start instructors off on the right foot are vital. A wealth of knowledge is available in research resources as well as in practitioner-oriented journal articles. More materials, video, vignettes, and model lessons are needed for problem-based and project-based activities. These resources must be leveraged for the growth of the integrated STEM community and the experimentation in engineering to move the field forward.
- We need ongoing professional development for instructors at all levels of education. We need freely accessible workshops for teachers at local, regional, and national universities, conferences, and other venues.
- Schools need to provide students opportunities to enact and extend STEM problem-based and project-based activities outside of formal school hours in informal education settings.
- To do these things, instructors need school administrators' understanding of their struggles and their support to move forward. This support might include time for professional development, team building, department integration, and coursework. We understand that for an administrator to support instructors adequately, high level administration must commit to the integrated STEM vision (e.g., school district policy, course release).

In our discussion we used the term "integrated STEM," but we used it in a way consistent with a similar term used by the International Technology and Engineering Educators Association (ITEEA). The ITEEA operationally defines integrative STEM education as "the application of technological/engineering design based pedagogical approaches to intentionally teach content and practices of science and mathematics education through the content and practices of technology/engineering education. Integrative STEM Education is equally applicable at the natural intersections of learning within the continuum of content areas, educational environments, and academic levels" (Wells & Ernst, 2012/2015; as adapted from Wells/Sanders program documents 2006-10).

We hope that you and your colleagues can discuss integrated STEM and ways you could use it in the places where you are teaching (e.g., Burrows & Slater, 2015; Vasquez, 2017). The following list is meant as a starting point, not an exhaustive resources list.

- TeachEngineering.org
- LinkEngineering.org
- ITEEA.org/Resources1507.aspx
- NextGenScience.org/

Please add resources in the comments for others to use as well. Together we can move STEM forward, but it will be with an understanding of the barriers and a commitment to trying something new.

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