THE ENGINEERS ARE TAKING OVER THE ASYLUM: STEM INTEGRATION IN K-12 CLASSROOMS

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Vexation

For better, or worse, the governor in Minnesota read and took to heart the National Academies' report, Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future (2006). This report details recommendations for enhancing the United States' science and technology enterprises. There is a growing concern that the U.S. is losing its competitive edge. The situation is exacerbated by continued drastic under-representation of minorities and women, as they do not enter the science and engineering at rates consistent with their populations. Enlarging the pipeline of students prepared to enter and successfully complete STEM coursework at the college level was a main focus of this report. A related report, *Tough Choices or Tough Times: The Report of the New Commission on the Skills of the American Workforce* (National Center on Education and the Economy (NCEE, 2007), categorically stated that "the core problem is that our education and training systems were built for another era, an era in which most workers needed only a rudimentary education." Our fast-moving, global, multidisciplinary industrial environments will require future graduates to not only have the traditional technical knowledge of their predecessors, but also a new and broader skill set. They will also need to understand and apply several disciplines to solve complex problems, adapt to new technology and changing situations, combine ideas to synthesize creative solutions, and work effectively on teams while having excellent communication skills (Corleto, Kimball, Tipton, & MacLauchlan, 1996; Shuman, Besterfield-Sacre, & McGourty, 2005).

These documents have lead to the recent creation of "STEM specialty" schools in Minnesota and a push for the promotion of technology and engineering standards in the state – not as separate, stand alone standards but embedded into the science standards. Both of these state level decisions are forcing K-12 schools and institutions of higher education to consider what it means to embed engineering into science courses or even more broadly to consider what STEM integration might look like in the classroom. And so the vexation, integration across STEM in K-12 classrooms, became a collaborative venture between schools and faculty at the University of Minnesota to bring engineering curricula to *all* students not just the high-achieving male students with pre-existing interests in STEM careers.

One of the obstacles to enlarging the STEM pipeline is simply getting students interested in these subjects (Jolly, Campbell, & Perlman, 2004). Arguments have been made that student interest can be gained by providing relevance through real-world contexts. A recent study that is part of the National Academy of Engineering Public Understanding of Engineering Project indicated several messages about engineering that tested extremely well with young children, teens, and adults in terms of overall appeal, believability and credibility (Baranowski & Delorey, 2007). They included, Engineers make a world of difference; Engineers are creative problem-solvers; Engineers help shape the future; Engineering is essential to our health, happiness and safety; and two strategic favorites emerged -- Because dreams need doing and Turning ideas into reality. Common arguments for K-12 engineering education include:

- Engineering provides a **real-world** context for learning mathematics and science
- Engineering design tasks provide a context for developing **problem-solving skills**
- Engineering design tasks are complex and as such promote the development of **communication skills and teamwork**
- Engineering provides a fun and hands-on setting that will **improve students' attitude** toward STEM careers.

These arguments form a compelling case for the potential of engineering education to make a significant and unique contribution to student learning, particularly for women and minorities.

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However, given that the inclusion of engineering in K-12 settings is fairly recent, there remain many questions that need to be answered. Mathematics and science teachers are concerned that they do not have the context expertise to implement engineering into their curriculum. And as a science educator, I remain cynical about the need to teach engineering in the K-12 setting and the power of engineering to teach science concepts.

Venture

So the issue for me was do I pick up the venture or just let the engineers take over the asylum? As a member of the new state science standards committee, it became clear that engineering standards were not open for discussion but that they will be part of the new science standards for Minnesota. The new standards will require high school students to take three years of science – a full year of biology, a full year of chemistry or physics, and a third year of science. This third year could be a full year of engineering – Project Lead The Way are already promoting their curriculum and despite the cost for schools to implement this is the current fad in Minnesota. So as science educators do we fight this trend or embrace this trend? And so for me the venture begins with the broad question in mind of "Can engineering be used as an integrating theme for students to learn across the STEM fields?" The venture will take us into both formal and informal settings but with the same question in mind, can engineering be used as a vehicle for teaching math and science.

The informal setting is a NSF funded ITEST project on the White Earth Reservation in Minnesota. This project brings STEM activities to students in grades 5-9 during summer and after-school programs. For five week this summer students worked on a variety of design challenge problems: launching a chemical rocket with an egg cargo that needs to return safely to earth, designing three wheel bicycles, an egg drop, and rubber band cars. We took the reasons for including engineering very seriously – there was real-world context (eggs symbolizing cargo on the Mars Rover), problem-solving (how many fins? How long should the rocket be? How big should the parachute be?), team-work, and not forgetting FUN. Students did a lot of measuring, data collection and graphing – many skills that can be "checked off" in the column of mathematics and science standards addressed in these activities. Yet, I am still left questioning whether the student learned scientific concepts during their project.

At this stage the venture is back on the drawing table with some more clearly focused questions for the project team: What are teaching strategies that facilitate learning across STEM in a single project? What is the right balance of instruction in the different STEM areas? How can projects be designed such that teachers can focus student attention on specific subjects at the appropriate time (when do we step away from the project formal to introduce a mathematics or science concept? How do we stop the activity getting in the way of student learning?