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A Rationale for Incorporating Engineering Education Into the Teacher Education Curriculum

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Investment in science, technology, engineering, and mathematics (STEM) education has been identified by the U.S. Department of Education and other agencies as a pressing need. Although science and mathematics, and to a lesser extent, technology-based learning opportunities have been important features of past educational programs sponsored by the National Science Foundation and can be readily found in K-12 curriculums, the E ("engineering") in STEM is underrepresented. Currently, few efforts are focused on an intensive, long-term, coherent approach to incorporating engineering content and methods into teachers' preservice or in-service professional development.

However, some schools of education are beginning to consider ways in which engineering might be integrated into the teacher education curriculum. The National Academy of Engineering (NAE) has convened a Symposium on K-12 Engineering Education[a] that will report the results of a 2-year study of the appropriate role of engineering education in the K-12 curriculum. The report will consider issues such as the role of engineering education in the K-12 classroom in contrast to engineering education in postsecondary institutions.

The NAE study reports that a small but vibrant and growing effort is underway to introduce kids to engineering in K-12 schools (the report details these efforts), through both formal (in-classroom) curriculum and informal (out-of-school) experience. Future efforts could build on this foundation but will be hampered by lack of preservice teacher preparation in this area.

Although much effort has gone into preparing high-quality teachers in science and mathematics, considerably less effort has focused on technology and even less on engineering in the formal curriculum. Due to the way in which the curriculum evolved, there is no course or set of courses for engineering that are the equivalent to "biology" or "algebra." Yet, everything around us that has been constructed and made available to make life better, safer, and more convenient has been engineered. New fields that integrate technology and engineering with traditional disciplines have rapidly arisen outside of formal K-12 education, with names like bioengineering and computational linguistics. The 21st-century global economy requires teachers who understand and can contribute to the literacy and preparation of students for full participation in these new fields.

Sherry Turkle, a professor in the Science, Technology, and Society program at the Massachusetts Institute of Technology (MIT), finds that science is often fueled by a passion associated with objects. Her students and colleagues often speak about the ways in which "they were drawn into science by the mesmerizing power of a crystal radio, by the physics of sand castles, by playing with marbles, by childhood explorations of air-conditioning units" (Turkle, 2008).

Her prescription for increasing interest in STEM subjects is to provide more opportunities for kids to interact with objects at an early age. Technological advances will make this increasingly feasible. For example, digital fabrication is the process of translating a digital design into a physical object. The Society of Manufacturing Engineering (2009) reports that advances in this field will soon allow "almost anyone to make almost anything anywhere" through digital fabrication.

Engineering is about designing solutions to recognized problems or needs. Solutions can be new concepts envisioned for the first time by anyone who sees the need and has an idea: an artist, a social entrepreneur, or an engineer. Taking a new concept from mind's eye to physical form is fulfilling and motivating in every field of endeavor. But students have not typically had the opportunity in school to see their concepts make the trip from concept to physical form, even though this skill, practiced in collaborative teams, is of critical importance to business innovation and competition on the global stage. The advent of emerging technologies such as digital fabrication potentially can give many more students this opportunity for the first time.

The U.S. President Barack Obama has identified this kind of innovation as the key to future prosperity. Thus, a new model of professional development for teachers is needed that is imbued with and that entails (a) the multidisciplinary literacies needed by the workforce and (b) a new conceptualization of the richness and depth of content knowledge needed for success in life and work. For example, on the side of content, science and mathematics teachers need to understand and use complex systems concepts, starting with simple systems and continuing to deepen as problems become larger and more unpredictable. In addition, teachers need to be able to facilitate inquiry for their students by grounding these concepts in practical and real problems (e.g., designing a more efficient wind turbine blade) while dealing with larger contexts in which these challenges emerge (e.g., addressing social and environmental concerns).

In the past the Society for Information Technology and Teacher Education (SITE) has formed special interest groups (SIGs) with connections to other associations in areas such as science education (the Association for Science Teacher Education [ASTE]) and mathematics education (the Association of Mathematics Teacher Educators [AMTE]) to allow us to work collectively to enhance teacher education across disciplines. These connections are reflected in the masthead of the *CITE Journal*, in our respective conferences, and in annual leadership summits with representation from each of these areas.

The area of engineering education is not yet represented in SITE's SIGs or in the National Technology Leadership Coalition (NTLC), a consortium of teacher educator associations (www.ntlc.org). However, in order to achieve key national and global educational goals, engineering education must be incorporated into the teacher preparation process. Hence, it may be time to add the "E" in STEM to the other three areas of science, technology, and mathematics.

There are several actions that might be taken to encourage and facilitate this:

1. A larger role for applied applications and engineering solutions in science and mathematics teacher preparation.
2. Opportunities in teacher preparation programs for all teachers (regardless of their subject area specialization) to experience team-based problem solving that requires innovation and the integration of disciplines on complex real world engineering problems.
3. The development of engineering education programs with corresponding licensure endorsements (including new licenses for multidisciplinary-capable STEM educators).

Currently, each STEM area is, for the most part, taught as a separate subject. Often these subjects are taught as intellectual puzzles with very little correspondence to real-world applications—in part, because of content standards specific to each discipline.

Changing this circumstance will require a reconsideration of standards and competencies better aligned with 21st-century skills such as problem-solving, collaboration, creativity, and leadership, and the way in which content matter is introduced. Realistically, a wholesale alteration of standards is unlikely. Therefore, this alignment will need to take place within the context of existing standards. Some potential models have been developed for ways in which this might approached. For example, David Burghardt, chair of Hofstra's engineering department, has worked to develop a STEM licensure endorsement for teachers in the state of New York.

Reconsideration of these standards may begin with discussion among the teacher educator content associations, educational technology associations, and engineering education associations, such as AMTE, ASTE, SITE, and the American Society for Engineering Education (ASEE). Formation of a SITE Engineering Education SIG can serve a first step in potential collaboration with other organizations that may have a common interest in addressing these goals.

Greg Pearson, a senior NAE program officer, notes,

The few studies that have been done on in-service teacher education for engineering have found considerable inconsistency and confusion concerning how best to enable teachers to teach engineering concepts. Thus, if preservice teacher education is to move forward, it probably should be accompanied by a major research component. (Personal communication, August 2009)

Engineering connections are largely absent in the current K-12 curriculum, but if done well could support greater student learning and interest in science and math. (There are some preliminary data suggesting that engineering curriculum can, indeed, improve math and science achievement compared with traditional science courses.) This strategy would mirror natural connections between engineering and the other STEM subjects (math, science, and technology) in the *real* world of research and development and technological innovation.

Notes

[a] Symposium on K-12 Engineering Education Web site: http://www.nae.edu/Programs/TechnologicalLiteracy/K-12EngineeringEducation/engineeringink12.aspx

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Author Notes

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