# Building Capacity for Preparing Teacher-Engineers for 21st Century Engineering

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In partnership with colleges of education and science, the College of Engineering at The University of Texas at El Paso [UTEP] has funding from the National Science Foundation [NSF] in the Robert Noyce Teacher Scholarship Program to build capacity for successful implementation of an undergraduate program in engineering to produce effective and knowledgeable teacher-engineers who understand current knowledge of how people learn and who implement pedagogical approaches using this understanding.

Background

In response to the 1983 national report *A Nation at Risk* (NCEE, 1993) calling for improved K-12 mathematics and science teaching and learning, major science and mathematics education reform occurred with the establishment of national science and mathematics standards (AAAS, 2008; NSRC, 2009; NCTM, 2012; NSTA, 2009). A major focus of these standards was the integration of inquiry-based teaching as a pedagogical strategy for improving student learning. In like manner, a second wave of educational reform is soon to take place in response to *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Future* (National Academies, 2007), which described the need for increased numbers of qualified scientists, mathematicians, and engineers to meet 21st century workforce demand. Furthermore, in 2011 the National Research Council (NRC) of the National Academies released the publication *A Framework for K-12 Science Education* (NRC, 2011) that addresses the need for further improvement of K-12 science education to develop a more integrated science, technology, engineering, and mathematics [STEM] curriculum to meet the workforce demand and to, more importantly, advance citizens' scientific and technological literacy.

While the impetus has been and continues to be on inquiry-based teaching and learning in mathematics and science, the new NRC framework embeds and integrates engineering and technology. Engineering provides a logical platform for applying and integrating scientific and mathematical concepts. This framework, as outlined in *A Framework for K-12 Science Education*, will influence change in the national standards that will now include four core ideas: (1) physical sciences, (2) life sciences, (3) earth and space sciences, and (4) **engineering and technology**. Thus, in the near future, engineering will soon be an integral element in K-12 classroom instruction as reform of state standards is expected to follow in the wake of reform at the national level, much as it did twenty years ago. This is the rationale for seeking engineers to become knowledgeable and effective engineering teachers at K-12.

Thus, the STEM national standards are expected to incorporate the recommendations of the NRC, which are likely to influence state standards. To meet these impending changes, this project redesigns engineering coursework in ways to deepen learning (Weiman, 2011), establishes professional development for university engineering faculty to redesign those courses, identifies relevant field-based work for engineering majors, and identifies successful activities of the existing UTEP Noyce scholarship program to prepare Noyce Scholars for the demands of K-12 classrooms.

## Project Goals

The overarching goal of the project is to build capacity within the UTEP College of Engineering, in partnership with the UTEP College of Education, to prepare for recruiting and certifying engineering students, which includes computer science majors, to become teacher-engineers. To meet this broad goal are the following two goals with respective descriptions:

> Goal 1: Build the infrastructure for producing effective and knowledgeable teacher-engineers who will teach in K-12 settings.

The program re-designs engineering course curricula with an aim of coupling these re-designed courses with existing education courses to eventually be integrated with field experiences in K-12 classrooms. Collectively these infuse a practice-based approach to learning to produce teacher-engineers who understand in deep ways the pedagogical and technical content of teaching, learning, and engineering.

> Goal 2: Strengthen partnerships among the university colleges and local school districts to support successful development of teacher-engineers.

A requirement for engineering students participating in the NSF Noyce Scholarship program is to ultimately teach in a high needs school. That is, high needs schools are ones that meet at least one of the following criteria: 1) majority of students are eligible for the federal free and reduced program, 2) more than 34 percent of the teachers are teaching out-of-field (i.e., do not have a degree in the field for which they are teaching), and 3) a teacher attrition rate of 15 percent or higher over the last three years. Thus, UTEP Engineering is developing partnerships among the three largest school districts in the community—all of which contain a majority of schools that meet the high-needs school criteria. Contractual agreements are being drawn up that will allow university students to participate in internships in their respective classrooms and to eventually accept a teaching position for a minimum of two years, which is a contractual agreement for the NSF scholarship program.

## Creating and Implementing a Theory-Informs-Practice Model

At the core of this project is the development and implementation of a theory-informs-practice model in which engineering and education courses will be tightly coupled. That is, the education courses set the theoretical underpinning for inquiry-based instruction, and the theory is practiced and realized in targeted engineering courses. Thus, the project supports faculty who attend professional development workshops on problem-based learning (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palinscar, 1991; Hmelo-Silver, 2004; Krajcik, Blumenfeld, Marx, Bass, Fredricks, & Soloway, 1998) and implement an engineering course re-design.

Re-designing curriculum using an inquiry-based learning approach is a vital step in addressing this serious gap in student achievement (Brooks & Brooks, 1993; Brown, Collins, & Duguid, 1989; Fosnot & Perry, 2005). A recent national report (Katehi, Pearson, & Feder, 2009) advocates identifying and introducing engineering content in school curricula to improve STEM learning by integrating mathematics and science education through engineering applications.

This report correlates with the NRC's recent release of the aforementioned A Framework for K-12 Science Education where engineering plays a pivotal role in applying mathematics and science content. Specifically, the goal of the NRC framework is as follows:

> to ensure that by the end of 12th grade, all students have some appreciation of the beauty and wonder of science; possess sufficient knowledge of science and engineering to engage in public discussions on related issues; are careful consumers of scientific and technological information related to their everyday lives; are able to continue to learn about science outside of school; and have the skills to enter careers of their choice, including (but not limited to) careers in science, engineering, and technology. (NRC, 2011, p. ES-1).

As STEM researchers assert in the NRC report, students need to function competently in a technologically driven world where applied science and mathematics, utilizing cutting-edge technology, are at the heart of solving many global problems. The report's vision of STEM education includes students developing "STEM literacy" (NRC, 2011, p. 166) through engineering because of its natural connections to science, mathematics, and technology.

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Conclusion

The project builds a unique infrastructure in UTEP Engineering incorporating inquiry-based learning both in theory and in practice. This research-based learning theory deepens students' conceptual understanding as they explore and make sense of phenomena on their own terms. Relevant education courses provide the theoretical underpinnings of inquiry teaching and learning, and the re-design of engineering course curricula from traditional lecture to problem-based learning (a form of inquiry) provides the practice of the theory. This theory-informs-practice model provides future teacher-engineers with the knowledge and experience to teach in such a manner that both engages K-12 students in their learning and exciting them about engineering as a career option.

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