

# Chapter 28

## Teaching MSE Students to Teach: A Design–Based Research Model for Introducing Professional Skills into the Technical Curriculum

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### ABSTRACT

*The purpose of this chapter is to show how design-based research (DBR) methodologies can be implemented in technical programs. First, the authors provide a background of recent research in interdisciplinary education, Integrative Graduate Education Research Traineeship (IGERT) programs, and design-based research. Second, a brief summary of the example case, a Pedagogy module which has been implemented with Materials Science and Materials Engineering students through an IGERT program, is discussed. The final portion of the chapter presents a new implementation model for DBR along with recommendations and strategies for interested faculty, department heads, or motivated graduate students to reform existing technical curricula using design-based research. The significance of the book chapter rests in the flexibility of this model to be adapted to any program, showing instructors the iterative process for developing a course to suit the needs of a department.*

### INTRODUCTION

Introducing non-technical courses into a cramped graduate engineering curriculum seems difficult, but ignoring “soft”—or more appropriately named, *professional*—skill development for scien-

tists and engineers of the future can slow or hinder the careers of otherwise well-trained graduates. Science and engineering graduates are expected to be articulate, strong communicators, good collaborators, and globally competent (Borrego & Newswander, 2010), but there continues to be a gap

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between expectations of technical employers and non-technical competencies of graduates, which will need to be remedied in future generations of master's and Ph.D.-level scientists and engineers (Meier, Williams, & Humphreys, 2000). Federally-funded programs such as the National Science Foundation's Integrative Graduate Education Research Traineeship (IGERT) seek to reform graduate education through the incorporation of interdisciplinary skill sets in order to overcome this expectation gap (Borrego & Newswander, 2010; NSF, 2013). An eight-week course was iteratively developed using design-based research (DBR) methods through which professional and interdisciplinary skills can be developed by students with STEM backgrounds to address this issue, which can serve as a model for other programs to implement other professional skills in doctoral curricula. First, a background of recent research in interdisciplinary education, Integrative Graduate Education Research Traineeship (IGERT) programs, and design-based research is presented. Second, an introduction to our IGERT Pedagogy curriculum shows the development of an eight-week pedagogy module over four years using a design-based research framework. Lastly, a new implementation model for DBR is presented that acts as a roadmap for other departments or programs to integrate any professional skills course into a technical curriculum.

## **BACKGROUND**

Despite an increase in complex, interdisciplinary engineering challenges (Borrego & Newswander, 2010; COSEPUP, 1995), academic programs and especially graduate level engineering education have continued in a more traditional route. Students are trained at the bachelor's level to work in an industry setting (ABET, 2013), and at the graduate level, to be experts in a narrow field or discipline, with little time devoted to interdisciplinary or professional skill develop-

ment (Golde & Gallagher, 1999; Manathunga, Lant, & Mellick, 2006; Morse, Nielsen-Pincus, Force, & Wulfhorst, 2007). Future scientists and engineers who can leverage knowledge, methods and procedures from a variety of disciplines are more creative problem-solvers than those that have been trained in a single discipline (Austin, Connelly, & Colbeck, 2001; Austin, 2002; Colbeck, 2008; Golde & Gallagher, 1999) as they are better prepared for actual tasks and innovation in their future careers (Youngblood, 2007). In addition to interdisciplinary technical skills, students involved in interdisciplinary programs boast student development of professional skills, such as communication skills, ethics, technical writing, and teamwork experience (Gamse, Espinosa, & Roy, 2013; Borrego & Newswander, 2010).

In response to this call for interdisciplinary research and reform of post-secondary science, technology, engineering, and mathematics (STEM) education to reflect this priority, the NSF instituted the Integrative Graduate Education Research and Traineeship (IGERT) program in 1997, which seeks to "catalyze a cultural change in graduate education, for students, faculty, and institutions" through the funding of innovative graduate STEM programs which seek to prepare interdisciplinary and professionally competent experts (NSF, 2013). In spite of NSF's laudable goals, many funded IGERT programs rely on a combination of traditional educational experiences to train their graduate students, including coursework, seminar series, and research components (Gamse et al., 2013; Graybill et al., 2006; Morse et al., 2007). Few IGERT programs intentionally integrate professional skill development within these activities (Van Hartesveldt & Giordan, 2008). Although some programs or universities may offer professional development resources, literature on the subject as a whole lacks either qualitative or quantitative evidence of implementation professional development into doctoral-level Materials Science and Engineering programs, as well as other post-secondary STEM disciplines.

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