Work in Progress: Establishing Formal Academic Programs in Engineering Education

Heidi Diefes-Dux¹, Deborah Follman², Kamyar Haghighi³, P.K. Imbrie⁴, Robert Montgomery⁵, William Oakes⁶ and Phillip Wankat⁷

Abstract - The national need for engineering education reform is widely recognized. Long-term and sustainable engineering education reform requires a pipeline for educating future engineering faculty and professionals interested in pursuing careers in K-12 teaching and administration. Purdue University is evaluating the development of a new framework for promoting engineering education reform. As part of this framework, new undergraduate and graduate degree programs in engineering education (B.S., M.S., and Ph.D.) are being considered. We will present for discussion a vision to legitimize, institutionalize, and advance the establishment of formal academic programs in engineering education and provide descriptions of the proposed programs, program coursework, admissions criteria, and anticipated job opportunities for graduates of such programs.

Index Terms - Innovative curricula, engineering education, research, scholarship.

INTRODUCTION

Long-term and sustainable engineering education reform requires a pipeline for educating future engineering faculty and professionals interested in pursuing careers in K-12 teaching and administration. Purdue University has created a new Department of Engineering Education and is evaluating the development of new B.S. M.S. and Ph.D. degree programs in engineering education to meet these very needs. These programs will combine advanced courses in engineering and education with research in engineering education. Graduates of such programs will be well-positioned for faculty careers at the K-12, community college, or university level as well as a variety of other careers.

VISION FOR RESEARCH AND DISCOVERY IN ENGINEERING EDUCATION

The call for engineering education reform is driving the need for the establishment of the field of engineering education as a scholarly endeavor. This call for reform is exemplified in the 1994 joint project report on Engineering Education for a Changing World by the Engineering Deans Council and Corporate Roundtable of the American Society for Engineering Education [1], the 1995 Report by the Board on Engineering Education of the National Research Council [2], and the recent call for change by the National Academy of Engineering (NAE) leadership [3]. The other significant development has been the adoption by the Accreditation Board for Engineering and Technology (ABET) of Engineering Criteria 2000 (EC 2000), a new set of program accreditation standards that replace the former focus on counting credits with an emphasis on formulating and assessing educational outcomes. These standards have intensified an interest in assessment reflected in a number of papers on the topic in engineering education journals. Moreover, as faculty members have come to recognize that changes in pedagogy will be needed to achieve the varied outcomes specified in EC 2000, many of them have undertaken the development and assessment of new methods designed to meet those outcomes. Thus, while EC 2000 does not directly require the scholarship of teaching, its adoption has led to a substantial increase in the number of engineering faculty members engaged in this form of scholarship, which has in turn led the engineering education journals to increase their sizes to accommodate dramatic increases in the number of papers submitted.[5]

The National Science Foundation has supported educational scholarship in engineering since the late 1980's through the Division of Undergraduate Education and the Engineering Education Coalitions program. Today, NSF support for engineering related education reform is in excess of $200M per year. Such support "has increased the status of educational research in faculty performance reviews, improved its quality by demanding appropriate assessment of results, attracted additional engineering professors into the arena, and increased collaborations between engineering professors and professors in disciplines like education and psychology."[5]
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Scholarly Activities in Engineering Education

In Scholarship Reconsidered [5], Boyer noted that mention of being “scholarly” brings to mind individuals involved in publication of basic research. And yet he notes that the term research only entered the vocabulary of American higher education in 1906. Until then, scholarship brought to mind a variety of different forms of creative work. Boyer called for a return to a broader definition of scholarship, which included the scholarship of discovery, the scholarship of integration, and the scholarship of teaching. He concluded that knowledge is acquired through research, through synthesis, through practice, and through teaching.

Within the field of engineering education, the scholarship of discovery, the scholarship of integration, and the scholarship of teaching are all relevant and seamlessly bound. To focus only on teaching is to trivialize the work and contributions of leaders in this field and the potential for the field to catalyze significant engineering education reform. While the term scholarship of teaching has come to mean more than the knowledge gained from preparing for and participating in one’s classes and the earning of a reputation for excellence in the classroom, it does not reflect the breadth of scholarly activity that occurs under the engineering education umbrella. These scholarly activities include but are not limited to:

- Quantitative and qualitative research on student learning and learning environments focusing on the abilities and skills engineering and pre-engineering students need to develop to be successful at each stage of their academic careers and beyond.
- Development, implementation, and assessment of new instructional models, materials, and learning environments.
- Dissemination of research results to a wide variety of audiences including engineering colleagues; math, science, and technology educators; and policy makers.
- Preparation of the next generation of faculty and professionals wishing to pursue work in the field of engineering education.
- Seeking and securing funding to support research activities.

Why in Engineering?

The history of efforts to bring the scholarship of teaching and learning of science, engineering, and mathematics into the content departments has been plagued the question "Why can't this work be done in the School of Education?"

Education research done by faculty in the Schools of Education tends to focus on the problems of teaching and learning in K-12 classrooms. Research in chemistry education, for example, has provided useful insight into the problems children have understanding heat and temperature or the problems high school students have when trying to master the task of balancing a chemical reaction. While this research is potentially useful for those who teach in the elementary, middle and high schools in the U.S. and abroad, it does not necessarily address the problems that faculty face when teaching sophisticated topics in science, engineering, and mathematics at the university level.

For examples of research that does address sophisticated topics focused at the university level, consider several projects recently completed by graduate students working towards a Ph.D. in chemical education at Purdue University in the Department of Chemistry. One graduate student completed a Ph.D. based on interviews that explored the conceptual understanding of thermodynamics by advanced undergraduates and graduate students in the Department of Chemistry. Another student built on this foundation to examine the problems that students in chemistry and chemical engineering encounter when studying quantum mechanics at the junior level. Although this work used methodology similar to the used by colleagues in the College of Education, it required a basic understanding of physical chemistry that is far beyond that commonly found among either faculty or graduate students in education.

Engineering education as a field of scholarly activity needs to be pursued by engineers. Because they are the heavy users of mathematics, science, and technology in problem solving and design contexts, engineers possess knowledge, understandings, and skill sets that characterize what is needed for success beyond school in the 21st century. Therefore, engineers are well positioned to take a leadership role in renewing, diversifying, and nurturing a cadre of talented leaders to guide the expansion of engineering education in K-12 and improve student learning across K-16.

References


