From the Margins to the Mainstream: The Emerging Landscape of Engineering Education Research

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In 2005, Kamyar Haghighi proclaimed engineering education research (EER) as a "new discipline" and urged the EER community to be "quiet no longer" (Haghighi, 2005). Although hundreds of EER-focused dissertations, dating back almost 100 years have been produced (Strobel et al., 2008) the EER community remained fragmented and relegated to the margins of the larger engineering community. Haghighi announced that a new age had dawned.

The recent emergence of EER as a coherent community has been well documented in the *Journal of Engineering Education* (JEE). The early and mid-2000s saw a flurry of activity focused on engineering education research, and the emergence of engineering education Ph.D. programs. In January 2003, JEE repositioned to become an archival journal for scholarly research in engineering education. The 2005 special issue of JEE, "The Art and Science of Engineering Education Research," celebrated the launch of the journal as an "engineering education research" journal (Felder, Sheppard, and Smith, 2005). Several JEE editorials have emphasized the urgency for systematically studying engineering education, and described strong indications of the readiness of the community (Fortenberry, 2006; Gabriele, 2005; Haghighi, 2005). An NSF-funded project, "Rigorous Research in Engineering Education: Creating a Community of Practice" (funded in 2004), confirmed very strong interest on the part of many engineering faculty members (Borrego et al., 2008; Smith, 2006; Streveler and Smith, 2006; Streveler, Smith, and Miller, 2005). A follow-up project is focused on expanding the EER community and has created the Collaboratory for Engineering Education Research, CLEER-hub.org (Streveler et al., 2010).

In 2005 three research universities, Purdue, Virginia Tech, and Utah State launched engineering education Ph.D. programs in their respective Colleges of Engineering, and a fourth institution, Clemson, has a certificate program in engineering and science education. A recent article documents the development of these engineering education departments and discusses the similarities and differences among the programs (Benson et al., 2010).

In addition to these established programs, several additional opportunities for students to earn doctorates in engineering education have recently emerged. U.S. universities with engineering education Ph.D. programs include Arizona State University, Carnegie Mellon, Clemson University, the Ohio State University, University of Washington, University of Georgia, Washington State University, and the University of Colorado at Boulder.

International contributions to EER are long-standing and continue to expand. The breadth of global participation is reflected in the growth of international associations partnering with JEE (ASEE, 2010a). Engineering education Ph.D. programs have also been developed in several countries, including Sweden, Malaysia, Mexico, and India and interest is high in countries such as Taiwan and Pakistan. A networking session for engineering education Ph.D. programs sponsored by the International Division of ASEE at the 2010 conference drew over 40 attendees (ASEE, 2010b). Another EER Networking session will be held at the 2010 Frontiers in Education Conference (Smith and Streveler, 2010) and we hope the conversation and networking will continue both online and at conferences.

Alternative pathways to engineering education doctorates are emerging, too. The University of Michigan launched an engineering education research certificate program in conjunction with their College of Education. The University of Minnesota, which has a College of Science and Engineering, recently launched a STEM Education minor in conjunction with their College of Education and Human Development. It is likely that many more institutions will develop engineering or science and engineering education Ph.D. programs.

The interest among prospective Ph.D. students is strong. Purdue University's School of Engineering Education currently has over 50 Ph.D. students, and 16 Ph.D. graduates. The graduates were all able to find employment. Virginia Tech as over 20 engineering education Ph.D. students and they, too, indicate that interest among prospective students as well as job prospects are strong.

All these factors point to growing commitment to EER globally. The strong indications of interest among prospective Ph.D. students, those currently enrolled in engineering education Ph.D. programs, faculty and prospective faculty, and higher education research funding agencies (especially NSF) heralds the beginning of a new era in EER. In a few short years, the community that once saw itself as marginalized is now entering the mainstream. Initial questions about where EER Ph.D.s might find jobs have been answered by the strong and diverse placement of graduates. Faculty with an EER research focus have earned tenure and promotion. Although some faculty in the EER community are still isolated and

undervalued, more and more institutions see EER as a legitimate and rewarding career path.

So where should a mainstream EER community be headed? Energy once spent on battles for acceptance can now be channeled towards other pursuits. We suggest some directions that may be most productive at this time.

- *Increased emphasis on knowledge building*
  Although there has been movement toward research topics that have value beyond an individual classroom, the body of EER literature that builds knowledge is still small. A broader knowledge of the educational, psychological, sociological, and anthropological literature is needed to be able to place EER findings within appropriate conceptual frameworks. This necessary increased breadth of knowledge of the learning and social sciences is best met through collaborations with experts in these fields.

- *Focus on meta-analysis and synthesis of previous work*
  Another way to assist in knowledge building is to synthesize the previous EER work to look for overall trends. Quantitative studies may be amenable to meta-analysis. Thematic analysis or grounded theory methods may help to synthesize qualitative data.

- *Development of engineering education-specific methodologies*
  Fensham (2004) posited that new disciplines should generate new methodologies. Currently, EER has been borrowing established methodologies from learning and social sciences and that is appropriate for a very new field. But this cross-disciplinary marriage of two distinct traditions has the potential to create intriguing methodologies. Some examples have already been seen (for example the creation of "pictorial personas" by Matusovich (Matusovich and Streveler, 2009) but more will undoubtedly arise and should be documented.

- *Look beyond the classroom for research venues*
  There is a perception by some that all engineering education research must be conducted within the confines of a classroom. Although the classroom may provide the most natural context for engineering education research, valuable studies can be conducted in the workplace and other contexts. Laboratory studies, as well as "clinical" settings, away from the classroom, may also be appropriate sites for data collection. For example, student interviews and think aloud protocols often are conducted in a neutral space that allows for confidentiality and comfort. We recommend that researchers consider these other options when designing their respective studies. It is also necessary to recognize that many variables that exist outside the strict boundaries of the classroom can have a strong impact on the learning environment and as such are appropriate areas of research. For example, the Center for the Advancement of Scholarship in Engineering Education (CASEE) has identified six research thrusts, including looking at the political, economic, and social influences on engineering education (NAE, 2010).

We have set out to trace the current landscape of engineering education research programs. The emergence of many new programs globally as well as the success of recent EER Ph.D.s and faculty provide evidence that the community is no longer marginalized but is heading toward mainstream acceptance. Exciting opportunities await us to build knowledge that will make a difference in engineering education curricula and pedagogy. At a time when the world is in dire need of engineers to design solutions to abate a widening array of environmental and social concerns, it has never been more important to investigate engineering learning and teaching. We hope that EER will continue to expand and move to the very core of the engineering community.

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