Impact of the Emerging Engineering Education Research & Innovation Community

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Impact of the Emerging Engineering Education Research and Innovation (EER&I) Community, a Work in Progress

Introduction

This paper is a report on a Work in Progress being conducted by the Engineering Education departments at Purdue University, Virginia Tech, and Arizona State University, which are collaborating on an NSF-funded program to document the impact of the emerging EER&I community. It describes the goals of the project, what has been done to date, what the participants have learned, and what remains to be done.

The goals of the program include;

(1) Identifying the broader EER&I network,
(2) Identifying examples of EER&I impact,
(3) Organizing and hosting a summit of EER&I leaders to develop a systematic process for documenting the impact of EER&I,
(4) Piloting the process, and
(5) Compiling and disseminating best practices.

The Engineering Education Research & Innovation community is growing and becoming well defined. It includes faculty, postdocs, and graduate students in engineering education departments or programs as well as those who are conducting engineering education research without being part of a formal engineering education program. The latter have been identified through their publications and participation in ASEE and FIE conferences as well as participation in the education divisions of their professional societies, funded research in engineering education, and interactions with faculty in established engineering education programs.

Examples of the impact of EER&I have been collected. Documentation of impact began with a quantification of the growth of the field, the numbers of faculty and graduates, research they are conducting, and publications resulting from that work. Such numbers are relatively easy to assemble, although keeping them updated is challenging in a rapidly growing field. The real measure of impact, however, is the change brought about in the way engineering is taught in all engineering disciplines and the change in the how engineering faculty across the disciplines value engineering education research. Documentation of those changes often takes the form of stories from or about individual faculty members who have implemented new strategies in their classrooms. Those stories are typically captured in videos or illustrated documents posted on websites.

An EER&I Summit held at Purdue University in September 2018 involved 30 EER&I community members and authorities on change or impact. Participants discussed metrics for determining impact of EER&I research, audiences that need to be aware of the impact on engineering education, potential systematic processes for documenting impact, and plans for piloting some processes for documenting impact. Metrics ranged from the relatively straightforward measures of the number of engineering education programs and productivity of those programs and individual researchers, which could be expected to have impact, to the more subtle changes in attitude toward EER&I and extent of implementation of the results of EER&I research, which would reflect the impact. Some of those subtle changes include attitudes toward who can/should be an engineer and how the engineering culture, and courses, can change to

broaden participation in engineering, how problem solving is taught, how empathy and ethics are incorporated into the engineering curriculum, and so on.

In order for EER&I to have impact, people from many audiences need to hear about the results and resolve to act on what they have learned. Some audiences identified were internal to the university and some were external. Internal audiences include faculty who are interested in adapting new approaches to teaching, faculty who are skeptical but curious, and administrators interested in utilizing research results or starting their own engineering education research programs. External audiences include students and parents who want to know how engineering will be taught at universities they are considering and faculty at other institutions who want to adopt/adapt changes made in response to EER&I research.

The process for documenting and communicating the impact of EER&I research depends on the audience. Tables of data on funded research, publications, and alumni employment rates are of potential interest to administrators. Most audiences are, however, more interested in stories about successes resulting from adoption of EER&I research results, presented either on video or in text and conveyed through websites, social media, selected publications, or conference presentations.

At the Summit, eight institutions indicated an interest in piloting a process for documenting and communicating the impact of EER&I at their universities. The institutions were of various sizes and types, large and small, public and private, campus-based programs as well as programs with a significant online component. All eight presented their plans for documenting impact at the ASEE 20019 Annual Conference. Since then, many pilots have moved forward. Some are described in the following sections of this paper.

Pilot #1. The pilot study conducted in the Department of Engineering Education at Virginia Tech sought to gather data that had not hitherto been collected in documenting the impact of the Department's activities in EER&I in the 15 years since its establishment. To this end, the project team sourced the following data:

- A record of all grants, external & internal awarded to members of the Department
- A record of all conference and journal publications authored by members of the Department
- A record of all positions, roles and offices held by members of the Department
- A record of the employment destinations of all Ph.D. alumni of the Department

These data were entered into a database which allowed for descriptive analyses to inform the pilot study. Key results of the study showed:

- Faculty have held a range of committee roles nationally in federal organizations (mostly the NSF) professional bodies (primarily the ASEE), conference organization (ASEE, FIE, IEEE and others); faculty have served on a range of advisory and editorial boards
- Research collaborations have been with a wide range of organizations including P-12 public schools, state bodies and other universities; nearly 150 research projects with total funding of over $40 million have been conducted

- During 2003-2018, the faculty members in the department published 164 papers in 62 journals and 368 papers at 34 conferences

- Of 42 Ph.D. alumni (total at the time of the study), all were employed, with 12 in tenure track positions, 12 in non-tenure track faculty positions, and the remainder in administration, research or industry positions.

Following this pilot, the team is keen to do further research on the Ph.D. alumni since their ensuing work is a significant and under-researched aspect of the Department's impact. Another line of research will seek to analyze the social networks represented in grants and publications, as the high levels of collaboration within the Department are considered a significant strength in enhancing impact. Further work will also seek to generate qualitative data to supplement the picture that has been generated so far of the Department's EER&I impact.

Pilot #2. NSF funded RED Participatory Action Research (REDPAR) is a collaboration between Rose-Hulman Institute of Technology and the Center for Evaluation & Research for STEM Equity at the University of Washington. Through facilitating connections and providing customized faculty development curriculum, REDPAR supports the work of teams funded through the NSF RED (Revolutionizing Engineering Departments) Program. REDPAR also conducts qualitative research with the RED teams on the change process across projects. Because of REDPAR's experience working with these change leaders, we have a high-level view of what is going on in the RED schools, and have some examples of the institutional and the national impact of RED.

At the institutional/individual team level, the teams are documenting their impact in many different ways. Because of the required inclusion of specific roles in RED grants, the roles of social science researcher, project manager, and engineering education expert have started to become more valued over time. Teams are seeing the value that the people in these roles bring to their change projects through facilitating, measuring, and guiding change processes. When new teams join the RED community, they have access to resources and advice from the REDPAR team as well as from the RED Consortium schools. Some teams in the more recent cohorts described the immense benefit of their first RED Consortium meeting. Attending the annual meeting at the start of their projects shortens their start-up time and increases early successes. In focus groups we hear about how teams are working together and learning from each other.

There is also qualitative evidence that the REDPAR-facilitated consortium is having national impact. REDPAR has created multiple Tip Sheets for practitioners which apply our REDPAR research findings to the organizational change literature and are freely available to all via our websites. We have witnessed increased collaboration across institutions. As a result of bringing together the RED grantee teams via the annual RED Consortium meeting and other ad-hoc gettogethers, new collaborative, inter-organizational research projects are starting, such as PaiRED. Because of our birds-eye view of the workings of the RED projects, REDPAR has provided advice and ideas to NSF about team needs and about how the funding mechanism can support and encourage this systemic change work moving forward.

Pilot #3. The Rising Engineering Educator Facility Experience (REEFE) is nearing its conclusion as two-year NSF-funded EAGER project comes to a close. During the fall semester 2019, a graduate student pursing a Ph.D. in engineering education at a research institution was placed for a REEFE at Cal Poly University, a teaching-focused institution. Their experience represents our final data collection for this project. As the project winds down, we are working on papers that will present our research findings from two studies. The purpose of the first study was to gain feedback from stakeholders in the engineering education academic community on the current state of professional development opportunities for engineering education graduate students. To this end, we conducted a qualitative study using the action research model to

determine essential characteristics and opportunities for improvement as they relate to the professional development of engineering education graduate students. From these results, we generated four key themes which also aligned with Austin's and McDaniel's model for graduate work [1]: knowledge, skills, attitudes, and connections. Importantly, these findings are enhanced by adding depth specific to engineering education and developing a list of practical implications for the engineering education community. This work should inform and bolster those interested in developing or assessing professional development in the field of engineering education. The second study used a case study approach to analyze pre-and post-interviews about graduate students' REEFE experiences, as well as the students' reflections on their experiences (in the form of blogs), to understand how the REEFE contributes to the development of the participants' professional identity. In this paper, we employ Kajfez's Model of Professional Identify Development [2]as a theoretical framework.

With the conclusion of this project, we are interested in finding a graduate program in engineering education or other academic partner who could take on the program and give it a "home" so that the benefits we have identified can be made available to other graduate students in the field.

***Pilot #4*.** The School of Engineering Education at Purdue University began documentation of its impact by gathering data such as the number sand demographics of engineering education faculty, graduate students, and alumni, number of CAREER and PCASE awards to faculty and alumni, leadership and editorial board positions held by faculty members, number and location of journal publications and conference presentations by people affiliated with the program, research expenditures, employment of alumni, and so on. Data were made available on the department's website and communicated broadly within the university and to the broader EER&I community.

The next step in the documentation process was to identify the School's EER&I programs that were leading to changes in existing courses and in how faculty teach those courses. The changes are being documented through video interviews with faculty members and students and interviews with alumni who are now teaching at other universities. The alumni share how they have changed engineering courses at their new locations. Data will be gathered on student success and retention in the classes where new techniques are being tested.

Concluding Remarks

The final goal of the collaborative NSF-sponsored program, compiling and disseminating best practices, will be realized by the end of Summer 2020 when the team gathers and integrates the results of the pilots, submits its report to NSF, and prepares journal and conference papers. In addition, links to websites documenting the impact of individual EER&I projects or Engineering Education programs will be made available to the broader EER&I community.

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