Research Initiation: Effectively Integrating Sustainability within an Engineering Program

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Research Initiation: Effectively Integrating Sustainability within an Engineering Program: Executive Summary

Abstract: This poster describes initial research into effectively integrating sustainability within engineering programs as well as efforts to build engineering education research (EER) capacity. Initial research focused on potential barriers to and opportunities for integration. This included a survey of engineering faculty and administrator attitudes toward integrating sustainability within engineering, as well as their attitudes toward engineering education research conducted by engineering faculty. Engineering student attitudes and dispositions toward engineering professional responsibility were also assessed via validated survey. An engineering course intervention, which integrates sustainability issues while covering fundamental engineering aspects of a contemporary issue, e.g., hydraulic oil well stimulation (fracking), was demonstrated and evaluated. Additionally, both local and international collaborative research opportunities were explored for multicultural K-5 education and integrating sustainability within higher education. EER capacity was also expanded through professional development activities and the creation of an institutionalized EER center, which organizes a local interdisciplinary community of scholars focused on engineering education.

Engineering Education Research Capacity Building

Professional development efforts included the PIs attending and hosting workshops on qualitative and quantitative education research methods, effective engineering pedagogies and energy education practices. Workshops attended included the National Effective Teaching Institute, the National Energy Education Summit and interinstitutional workshops focused on increasing diversity within engineering. Additionally, the PIs teamed with faculty in Education to host a full-day workshop on quantitative and qualitative research methods in education, in which 18 engineering faculty actively engaged. All attendees at the full-day workshop reported improved knowledge of engineering education research methods, agreed it was a valuable use of their time, and would advise colleagues to participate in a future workshop. Moreover, results from faculty surveyed as part of this project indicated overwhelming support for EER and helped motivate the establishment of a new EER center at the PI's institution.

In 2017, the PI travels to University of Otago in Dunedin, New Zealand to meet with faculty in the Higher Education Development Centre, one of the oldest centers of its kind in the world. Subsequently, the PI will also visit leading engineering education researchers at the University of New South Wales in Sydney, Australia and University of Western Australia in Perth, Australia. These activities will result in new interdisciplinary, multi-institutional and international collaborations and significantly improved EER capacity.

Engineering Faculty and Administrator Attitudes

Adapting a survey originally used to evaluate university faculty thoughts on education for sustainability (Shephard, et al.), engineering faculty, including department heads and the dean at the PI's institution (a public, land-grant university) were surveyed on their attitudes toward integrating sustainability within engineering programs, as well as their attitudes toward EER conducted by engineering faculty and the creation of a related research center. The survey

contained 20 multiple choice items with a 5-point Likert scale, along with demographic questions and opportunities for open-ended comment. The survey was administered via Qualtrics and emailed to 141 individual faculty, with 67 completed surveys analyzed. Results indicated that faculty are generally supportive of EER and the establishment of an associated research center. Results also indicated that faculty are generally supportive of integrating sustainability within engineering education (their classes), but desire training opportunities to do so effectively. There was a small fraction of respondents who are skeptical of the effectiveness of EER, and its legitimacy as a professional endeavor for engineering faculty. A similarly small fraction of respondents are also skeptical about human caused climate change and its threat to humans. Survey data were communicated to the dean and helped motivate a new EER center. The data also provided a baseline assessment of faculty attitudes and dispositions toward integrating sustainability in engineering curricula.

Engineering Students' Professional Responsibility Assessment

Senior engineering students within one department at the PI's institution were asked to complete an updated and validated survey instrument, the Engineering Professional Responsibility Assessment (Canney, et al.). The survey was administered via Qualtrics and emailed to 144 students; 35 completed surveys were analyzed. Results indicated that student's choice of engineering major was significantly motivated by: the passion for and aptitude in science and math; interest in problem solving; good career choices; contribution to societal problems such as climate change; and, the perception that the engineering profession helps society. Students identified specific courses within the engineering program which strongly influenced and/or reinforced these motivations. Students were also asked to define social responsibility and describe university courses or experiences which influenced their opinions on social and professional responsibility. Students commonly referred to social responsibility as a sense of obligation to protect communities and societies and often mentioned courses outside of engineering which reinforced this sense. Interpretations of survey data are being leveraged for continued research efforts and helping guide curriculum development.

Development of Modular Sustainability Inventions for Engineering Courses

Engineering education often focuses on technical aspects of the design, construction and operation of systems to solve problems. However, this technical focus can be at the expense of improving students' awareness and understanding of the complex, multi-scale impacts these systems can have on the environment and society. The intervention demonstrated and evaluated in this project was intended to objectively address a complex, contemporary and often contentious issue in engineering practice: hydraulic fracture oil/gas reservoir stimulation for enhanced production, or "fracking". The aim was to compare and contrast responses from three unique cohorts of students to the same classroom intervention: a university core-science course with no prerequisites comprised of 77 students with mostly non-STEM majors; a core-chemical engineering program course with 35 sophomore/junior-level engineering students; and, a 20 student, senior-level engineering technical elective course.

The intervention included baseline assessment of students' understanding of and opinions on fracking, presentation of two video tutorials on fracking (one from an industry group, one from a non-profit science-literacy organization), and subsequent student group research (online and during class) within five separate focus groups: science/technology; environment; social/health; policies/politics; and, economics. Following the group research, consensus statements from each group were openly discussed and summarized, and students' understanding and opinions on fracking were reassessed.

In general, the students' basic understanding of fracking improved significantly, their opinions on the topic shifted from neutrality, and the majority agreed that the course format was effective in their learning of both technical content and the sustainability implications. Data from this study, including detailed responses to open ended questions, are being analyzed in collaboration with faculty and students in Sociology at the PI's institution. Results of this study will be used to inform future studies and the development of transferable course modules, which include rigorous engineering content and social/economic/environmental (sustainability) implications of engineering practices.

Multicultural K-5 Engineering Education Efforts

Collaborations have been developed with faculty in Education and Psychology to explore what K-5 students, educators, administrators and parents think about the engineering profession, using tools like "draw an engineer" and "attitudes toward engineering" (Cunningham, et al.). This group has also investigated refining K-5 engineering education frameworks to help K-5 teachers develop curriculum that concurrently addresses next generation science standards and state-mandated indigenous education requirements. Opportunities to expand and research the effectiveness of multicultural K-5 engineering education are being explored, with baseline data being collected. Moreover, the PI's travel to New Zealand and Australia will help inform future studies based upon successes these collaborators have had incorporating indigenous epistemologies and ontologies within engineering and engineering education.

Summary

This NSF-RIEF grant has significantly spring-boarded EER efforts into the effective integration of sustainability within engineering programs at the PI's institution, and elsewhere. The PIs are teaming with local and international experts to expand research efforts into measuring student and faculty attitudes toward sustainability and developing and refining engineering course interventions that integrate sustainability while covering technical content. These efforts will help build understanding of challenges and opportunities to integrate sustainability within engineering, which has been demonstrated to recruit, retain and better prepare more diverse engineers to help solve wicked problems. Furthermore, the grant helped motivate a new EER center to catalyze and facilitate more interdisciplinary research on these and other topics.