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Innovation through Propagation: A Roadmap for Engineering Education

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Work in Progress - Innovation through Propagation: A Roadmap for Engineering Education

Introduction

A series of blue ribbon reports has laid out a challenge for engineering education, *raising awareness* for both what is *needed* to change and the *context* (e.g., K12 versus higher education). As documented in a recent ASEE report[i] (2012) also lacking is successful propagation, including a challenge to funding agencies to better exert their role in the propagation of proven successful efforts. That is, propagation should not be simply the dissemination component of research, but also part of the research.

We report on an NSF funded study that dives into *specific key areas to strategically and tactically determine how best to realize propagation of engineering education innovations.* Specifically, we wish through a broad outreach process and the commissioning of three papers to delineate research directions in engineering education that would best propagate documented innovations. Those papers emphasize three critical areas:

- Learning in and out of the classroom;
- The pathways to studying engineering, retention, and diversifying learning community; and
- Using technology to enhance learning and engagement.

The NSF is committed to establishing and the engineering education community is in need of a research agenda focused on propagating documented innovations. To most effectively accomplish this, it is necessary to capture needs and potential solutions through a number of different approaches that actively involve the larger engineering education community. As such this work addresses four major questions.

1. **What accomplishments have been produced to date?** What new innovations have occurred over the past one to one-in-half decades that have lasting value in engineering education?
2. **To what extent have innovations been propagated?** Have meta-analyses of certain funded innovations across the key areas gleaned useful understanding of how propagation has or has not occurred?
3. **What remains to be done**? What are the gaps in the research? What are potential root causes as to why the particular innovations have not proliferated across engineering schools?
4. **How best can future work be propagated**? What type of research agenda is needed over the next five to ten years to facilitate that innovations in engineering education spread across different types of engineering schools, engineering disciplines and engineering coursework? What evidence is required to document a successful innovation?

Engaging the Community – Our Processes

A major emphasis of this project has been to engage audiences of the engineering education community (e.g., engineering education researchers, early adopters of engineering education innovations, engineering administrators who will promote propagation). During year one of the effort, we engaged the community via three primary processes. The first two processes involved a Delphi study with subject matter experts (SMEs) from across the engineering education research and administrative spectrum. The purpose of the Delphi study (conducted during the winter and spring of 2015) was to identify the most critical unresolved issues facing engineering

education research and it propagation related to each of the areas; and to identify persons that can best discuss these issues. The Delphi consisted of three rounds, where the first round openly asked the two mentioned questions. Researchers coded the open-ended responses and created a closed form instrument of identified issues by which the SMEs rated the importance each might have on research and its propagation.

Between the second and third round of the Delphi, a highly interactive session at the ASEE 2015 Conference was held. The results of the study were presented; and additions and critiques from the over 75 participants were obtained. During the final round, SMEs reviewed both the collective SME ratings along with the feedback from the ASEE session participants. They then provided their final ratings.

From the Delphi study results, three writing teams, each addressing one of the critical areas, were commissioned. The teams utilized the Delphi results as well as literature and their own expertised knowledge of the area to formulate initial thoughts and ideas on the critical issues and potential research avenues. The writing teams presented their thoughts at a workshop (our third process) with leading engineering education researchers and administrators during the fall 2015. Workshop participants were selected based on their particular expertise in one of the three areas, as well as their contributions to engineering education (i.e., engineering education researcher, innovative engineering education practitioner, engaged administrator in engineering education). During the two day workshop, the participants discussed at large the initial thoughts of the writing teams; and then separated into smaller groups, led by a consultant expert in each of the three areas, to think further about the ideas presented in light of the larger group discussion. Issues discussed during the early session were then posited into potential research plans to further thinking around the issue. By the end of the workshop, participants had broad-spectrum agreement on the issues and considerations for how research on these issues may be conducted. Further, the writing teams had armed feedback for their position papers that will inform the engineering education community and its various audiences (e.g., researchers, practitioners, early adopters, and administration) future directions of engineering education research and its propagation.

Moving forward, the community involvement for this 2016 year began with setting the stage for the papers that the writing teams are engaging in. To initiate this process, the writing teams have developed work-in-progress papers as part of their larger paper to discuss with the engineering education community at the 2016 ASEE. A community session is being held where these Work-in-Progress papers will be presented together , followed by a World Café style approach where participants can engage and discuss with the authors the issues; thus, providing additional feedback from the community. Once drafts of the position papers are completed, they will be vetted with the community via reviews with the project's advisory board, as well as through an extended review process as a special issue of the *Advances in Engineering Education (AEE)*. In addition, additional experts will be invited to provide responses to the papers as part of this special issue of the *AEE*. To provide dissemination beyond a special issue of the *AEE*, YouTube videos will also be developed and sent to the targeted audiences regarding the three critical areas.

Delphi study results, three commissioned papers journal papers and their responses, the ASEE 2015 and 2016 feedback from participants at large, and the results of the workshop will be

combined to produce a final report. This report will also be an iterative process that involves multiple opportunities for community feedback.

Overview of the Critical Areas and Their Issues

As mentioned, three areas critical to the NSF are: (1) Learning in and out of the classroom; (2) The pathways to studying engineering, retention, and diversifying learning community; and (3) Using technology for enhancing learning and engagement. Through efforts discussed, the three writing teams are each addressing three to five issues that should be tackled if propagation of engineering education innovations is to occur. Each writing team has submitted a WIP that elaborates on and rationalizes why these issues, as well as in offer initial ideas on research questions. We provide the issues here in summary form.

Learning In and Out of the Classroom: The framework for organizing the research includes four primary issues.

- Changing the culture;
- Catalyzing conversations about learning outcomes;
- Promoting adaptation; and
- Improving faculty development. In the following sections, we rationalize choice of these four issues and offer sample research questions related to each issue.

Improving and Diversifying Pathways: Five primary issues and needs have emerged related to improving and diversifying pathways of engineering students as follows.

- Studying the root causes of why engineering remains a primary white, male field; and identifying institutions that have successfully broken the stereotype.
- Identifying and studying those engineering schools and programs that have made substantial progress in increasing under-represented student populations and determine their best practices.
- Initiating and synthesizing engineering education research focused on the "neglected" cohorts (e.g., LGBTQA, disabled, low income).
- Determining why certain engineering fields are more attractive to under-represented cohorts.
- Examining the culture and faculty attitudes of those engineering areas that are least diversified and those that are highly diversified in order to identify best practices and incentives for changing the culture and climate as a first step of increasing the pipeline.

Using technology to enhance learning and engagement in engineering: For systemic change for integrating technology in engineering education, three issues were identified.

- Aligning the development and use of technology with learning processes (e.g., meaning making, disciplinary practices) and with equitable student engagement.
- Addressing faculty pedagogical beliefs, to help develop faculty technological pedagogical content knowledge, and to connect the two.
- Identifying and implementing systematic uses of process and learning data to inform formative and summative assessment, adaptive instruction, and research of learning engineering.

Broader Impacts of this Work

The purpose of this work is to understand the landscape of current educational innovations and form an effective research agenda that can propagate engineering educational innovations across the community and to the other STEM fields. Hence, broader impacts will be fully realized upon actuation of the research agenda. However, this work moves beyond broader impacts in that it assists in meeting a national need to increase the U.S.'s economic competitiveness, the STEM workforce, and potentially partnerships between academia and industry. It is in this latter sense that the project clearly meets the national need to remain economically competitive.

References:

[i] American Society for Engineering Education (ASEE). (2012). *Innovation with impact: Creating a culturefor scholarly and systematic innovation in engineering education*. Washington, DC: American Society for Engineering Education.