PROJECT SUMMARY

CAREER: A Study of How Engineering Students Approach Innovation

Despite the crucial link between engineering and innovation, research on engineering education in innovation is limited. The challenge, however, is not the volume of studies on this topic, but the integration and application of research. Prior studies conducted by cognitive scientists, design researchers, and business scholars highlight some of the individual characteristics important for creativity, characteristics of innovators and entrepreneurs, and the critical role of organizations in supporting innovation. However, very little is known about how **engineering students approach innovation** and ways to **measure these processes and their outcomes**. Hence, this study will examine engineering students' cognitions, motivations, and predispositions using interviews and think-aloud protocols. Their processes will then be analyzed to identify possible curricular, gender, and cultural differences among students.

Research Questions

- How do engineering students approach innovation? How do gender and cultural differences shape the approaches students use or talk about and the solutions they propose?
- To what extent do engineering students understand the process of innovation and recognize skills used by innovators?
- In what aspects of innovation do senior engineering students who are enrolled in an entrepreneurship and innovation (E&I) certificate program differ from seniors and first-years who are not enrolled in E&I?

The *research* component of this project uses a sequential mixed methods approach. Interviews and verbal protocols will be used to characterize to what extent engineering students know, possess, or use skills held by innovators. Students' approaches to innovation and understanding of key aspects of innovation process will be analyzed using pair-wise comparisons between groups of first-year engineering students, senior-level students who are enrolled in the Certificate in Entrepreneurship and Innovation (EI) program, and senior-level students who are not enrolled in this program. Gender-based and cultural differences will also be analyzed. These analyses will be done by comparing coded frequencies using ANOVA, followed by a multiple case study with a cross-case analysis. A key outcome of these analyses is a data-driven framework for engineering students' approaches to innovation.

The *educational plan* will focus on faculty professional development, as well as on curriculum and assessment design. To facilitate this, faculty workshops will be held on Purdue campus as well as at NCIIA and ASEE conferences to reach those who engage in innovation and entrepreneurship programs and education of engineering students. These workshops will tackle common misconceptions about how engineers innovate and educate faculty about how to assess effective innovation processes and products of innovation. Classroom assessment tools of innovative design processes and outcomes will be developed based on findings from the previous phases. In addition to college faculty, workshops will be offered to K-12 teachers through PBS teacher line and face-to-face presentations. These are programs the PI is already involved in.

Intellectual Merit. This project will contribute to the education and training of innovative engineers and hence continuous growth of our economic viability by producing research on how engineering students innovate and how educational interventions support these skills. By connecting research from diverse fields and building on the interdisciplinary background of the research PI, this project has a robust research framework and research design. The advisory board, composed of experts in all aspects of the study, will contribute to the research rigor as well as the dissemination of findings. The proposed research design will be an example to guide future studies involving the assessment of other difficult constructs.

Broader Impacts. Although not all students need to be entrepreneurs, all students would benefit from learning to be innovative. To be prepared for 21st century engineering, students need the skills to innovate. The examination of gender and cultural differences will help develop a comprehensive and inclusive model of engineering student innovation. This research will contribute to engineering change by measuring and understanding student learning in becoming innovative and equipping educators with tools and resources to perpetuate this change. Benefits to more than 2000 students nationwide is expected in the short-term through the research dissemination and faculty workshops. The research findings will be presented at conferences such as ASEE, FIE, NCIIA, and AERA and published in engineering education journals. Innovation is a key skill necessary for all engineers, and essential to the prosperity of our society. To support wide dissemination, the results of the research project and curriculum and assessments developed will be available on NSF-funded collaboration/academic networking sites such as the CLEERHub (cleerhub.org) and Engineering Pathway.