BOARD # 444: RIEF: Understanding Impacts of Undergraduate Research Experiences in Human-Centered Engineering on Attitudes and Career Interests of Students with Physical Disabilities

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RIEF: Understanding Impacts of Undergraduate Research Experiences in Human-Centered Engineering on Attitudes and Career Interests of Students Working on Assistive Technologies

Abstract

This paper describes an effort aimed at understanding and highlighting the relationship between robotics and students underrepresented in engineering in a new setting: undergraduate research. Recently, a unique research community emerged as a result of two previously funded projects: (1) a soft robotics undergraduate research group for students underrepresented in engineering and (2) a robotic wheelchair project called Personalized Unique Rolling Experience (PURE). The PURE project has educational goals for undergraduate students and created a dedicated maker lab on campus. Both projects have attracted students with physical disabilities to participate in undergraduate research working on assistive technologies without direct recruitment. We aim to use qualitative engineering education research methods developed in the NSF RIEF program, to study this unique cohort to understand supports and barriers for students with physical disabilities to contribute to research. Grounded in Social Cognitive Career Theory we set out to understand factors that influence research in human-centered engineering design as a support for career success for students with disabilities. The research design set out to answer the research question, *What factors impact self-efficacy and career interest as a result of a human-centered robotics design research experience?*

Introduction

This supplement project is examining the relationship between robotics innovations and students underrepresented in engineering in a new setting: undergraduate research. This project was conducted in response to a unique research community that has emerged because of two previous funded projects: (1) a soft robotics undergraduate research group for students underrepresented in engineering (NSF #1830896) and (2) a robotic wheelchair project called Personalized Unique Rolling Experience (PURE) (NSF #2024905). Both projects have attracted students with physical disabilities to participate in undergraduate research working on assistive technologies. In this project, we used qualitative engineering education research methods developed in this NSF RIEF project, to understand supports and barriers for students with physical disabilities in research. We aim to study undergraduate research as a support for students with increasing confidence, and awareness of STEM opportunities. We hypothesized there are unique aspects to having a high proportion of students with disabilities in research *and* a cohort that emerged authentically without direct recruitment.

The PURE project is based at University of Illinois Urbana Champaign. Here, approximately 45% of College of Engineering undergraduate students participate in research on or off campus. Research experiences of students with mobility-limiting disabilities are understudied, resulting in few supports and pathways for this group [1]. While students with and without a variety of disabilities enroll in STEM majors at similar rates, students with disabilities complete STEM degrees at lower rates, fewer go on to graduate school, and of those that graduate, fewer are in technical science and engineering jobs [2]. One study found that students with disabilities experience feelings of alienation on college campuses exacerbated by barriers to pursuing

accommodations [3]. But STEM self-efficacy, or an individual's belief that they can be successful in STEM, was increased when mentoring strategies were tailored to students' specific needs [3]. Having a diversity of perspectives including those of engineers and designers with disabilities will broadly benefit end users and the design process [4]. The inclusion of undergraduate students with physical disabilities in this project will reveal insights to promote persistence, graduation and STEM career interest for this group underrepresented in STEM.

An important outcome of undergraduate research is the change in how students think about their discipline, career options, and how they can contribute to the world [5]. Student career choice within STEM can be understood using Social Cognitive Career Theory (SCCT). SCCT is a framework of career development that explains how personal inputs, contextual affordances, and social cognitive variables impact the formation of career interests, goals, and actions [6]. The undergraduate research learning environment can impact career choice, by influencing persistence in STEM [7] and pursuit of graduate degrees [8]. We believe that research in human-centered engineering design fields can be particularly influential for students when evaluated through the lens of Critical Engineering Agency (CEA). The CEA framework is used to understand students' subject-related identities and engineering agency beliefs [9]. Engineering agency beliefs refer to student attitudes toward engineering as a tool to serve their communities [10]. By studying identity and agency beliefs in the context of research and its impact on SCCT may enhance understanding of supports and barriers for students with physical disabilities. Women's agency beliefs hypothesized to account for high enrollment of women in bioengineering because connections to impacting people is clear [9]. We hypothesize that participation in fields that put human-centered engineering design at the forefront, even outside bioengineering, may align with agency beliefs, and promote persistence.

Methods

Intervention

With this supplemental funding, we engaged current undergraduate students with and without physical disabilities in a paid research experience on the PURE team. The goal of this supplement is to study supports and barriers that attracted these students to conduct research in assistive technologies.

Engineering Education Research Methods

To understand the impact of this research on mentors and students, we used a qualitative study design. The technical activities outlined above will allow us to investigate the research question: *What factors impact self-efficacy and career interest as a result of a human-centered robotics design research experience?* We conducted pre- and post-program interviews. The data collected is being used to analyze the current program implementation, mentoring and inform future work on human-centered robotics as a tool to increase persistence in engineering. As an alternative to technology-focused design, human-centered design considers stakeholders more broadly than stereotypical users [11]. It has been noted that the ability to show empathy may have as significant an influence over an engineer's career path as technical competencies [12]. All study procedures are approved by Illinois IRB (#24-1046).

Pre-interview survey measures Prior to the semi-structured interview, participants completed a short survey using the measures described here. Undergraduate Research Student Self-Assessment scale developed by University of Colorado Boulder [13] evaluates skills-based student outcomes of undergraduate research experiences. Researcher Identity measures [14] include prompts to reveal students' identities as researchers and perceptions of these identities as developed through research. Engineering career choice is measured asks students to "Rate the likelihood of choosing a career in" STEM related careers and eight specific engineering disciplines [9]. Five items measure students' engineering agency beliefs, perceptions of their ability to think critically about engineering and use it to do good in the world [9].

Qualitative Interview Design Individual semi-structured interviews were conducted with participants, including undergraduate researchers on the PURE project with and without disabilities. The objective of each interview is to understand individual factors that contribute to changes in identities and career interest measured in the surveys. Additionally, the interviews aimed to assess student perceptions of the research project and its influence on career choice. Example questions include "*What influences your choice of research project and laboratory?*" and "*How did you use aspects of your identity in developing engineering solutions?"* Probe questions elicit rich descriptions that support data quality. To understand the context under which the research took place, mentoring strategies for students with disabilities, and perceptions of intervention success, we also interviewed graduate student mentors. Questions included, "*What was your experience adapting to the needs of your mentees*?".

Data Analysis Open-response survey questions and qualitative interviews will be analyzed by thematic analysis [15] and provide explanations of responses to survey findings. The qualitative analysis also includes developing analytical memos in all phases of data collection for rich descriptions of themes based on data insight and emergent interpretations. Data analysis will triangulate three data sources: survey and interview responses, the research team analytical memos from surveys, interviews, and research artifacts.

Outcomes and Findings to Date

To date we have supported five semester-long research internships for students working on assistive technologies and robotics. We have also trained a new engineering graduate student in education research methods including survey development and analysis, semi-structured interviews and qualitative data analysis. During this supplemental project, we were able to use new engineering education research method skills developed during the NSF RIEF project in a new context. We collected data on student perceptions of supports and barriers in research, identity as it relates to human-centered design, and working with end users in the design process. Additionally, as a result of this project, barriers in laboratory courses were identified and one student is collaborating with the team to publish best practices for lab courses for students with disabilities.

This supplemental project is part of a larger NSF RIEF study. To date we have delivered a soft robotics module three times in schools. Once as a pilot at a small, public high school [16] and twice at the larger, public high school of study. We have published the teacher-informed curriculum to the K12 teacher community [17]. The school of study also now has a section of the library dedicated to stories of diverse scientists and engineers to support inquiry and provide

resources for students outside of the science classroom which also houses a maker space and supports student research and projects. The science department chair we partnered with in the study started an engineering club and continues to conduct the hands-on activities with students at the school. We've had the opportunity to use the intervention developed for this project in outreach contexts [18], [19], [20], [21], and as part of an undergraduate soft robotics course [22]. We also delivered a workshop for a broad community of teachers at the ASEE Pre College Engineering Education Pre-Conference [23]. Data analysis continues. We see soft robotics curricula as a potential to increase diversity in robotics across the educational spectrum.

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