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BOARD # 284: NSF REU Site on Inclusive Innovation in Medical Devices – Outcomes and Lessons Learned

Dr. Yanfen Li, University of Massachusetts Lowell

Dr. Yanfen Li is an Assistant Professor in Biomedical Engineering at the University of Massachusetts Lowell. She received her Ph.D. in Bioengineering from the University of Illinois at Urbana Champaign in 2018. Dr. Li has extensive experience in engineering education focusing on recruitment and retention of underrepresented and under resourced students and engineering pedagogy. Her work spans the areas of curriculum instruction and design, program design and evaluation, and the first-year college experience.

Walfre Franco

NSF REU Site on Inclusive Innovation in Medical Devices – Outcomes and Lessons Learned

Abstract

The NSF-funded Research Experiences for Undergraduates (REU) program on Inclusive Innovation in Medical Devices at the University of Massachusetts Lowell aims to engage undergraduate students in cutting-edge, multidisciplinary research at the intersection of engineering, biology, and medicine. This program provides hands-on research opportunities in biomedical engineering while simultaneously addressing the broader impact of societal needs in healthcare.

The REU program's core objective is to empower students to tackle real-world healthcare challenges by designing and innovating medical devices. Throughout the ten-week summer program, participants are exposed to both laboratory research and professional development workshops, equipping them with technical expertise and communication skills. Key research projects include mobile phone-based imaging for diagnostics, biomaterial development for tissue engineering, and computational modeling of respiratory devices. Key professional development events include research a jump start seminars, technical writing workshops, communication workshops, microagression training, and a final poster presentation event.

Preliminary findings indicate significant growth in students' research self-efficacy, with a notable increase in their ability to discuss research at professional meetings and conferences. Additionally, participants expressed heightened confidence in pursuing graduate studies in STEM fields, further solidifying the program's role in shaping future biomedical innovators. The program's emphasis on inclusion has proven essential in cultivating a diverse talent pipeline ready to address the healthcare needs of tomorrow.

Introduction

Undergraduate research has been shown to have positive impacts in Science, Technology, Engineering, and Mathematics (STEM) education including increasing students' self-efficacy, interest in STEM, and retention within STEM[1]. Participating in undergraduate research at an external institution, like participating in a Research Experience for Undergraduate (REU) program, can be especially positive for students[2]–[4]. This experience allows students to engage with diverse research environments, methodologies, and perspectives that might differ from their home institution. This exposure can also enhance adaptability and problem-solving skills while helping students build a larger network of mentors, letter writers, and peers across institutions. Such experiences are invaluable for career development, helping students strengthen their résumés, explore potential graduate programs, and gain insights into different research cultures and practices, making them more competitive for graduate school applications.

The REU program at the University of Massachusetts Lowell (UMass Lowell) focuses on Inclusive Innovation in Medical Devices, an important topic in biomedical engineering. Research in medical device innovation focuses on the development, optimization, and implementation of technologies to improve healthcare outcomes. This broad topic encompasses a wide range of

research projects ranging from diagnostic tools, to prosthetics, to imaging systems. The REU program at the University of Massachusetts Lowell focuses on innovative engineering of medical devices from a biomedical engineering perspective which includes a comprehensive understanding of engineering methods, clinical requirements, and physiological environments. Teaching inclusiveness within this field is vital because these innovations directly impact diverse populations worldwide. Inclusive practices ensure that devices are designed with consideration for a wide range of users, including individuals from underserved communities, those with disabilities, and people from diverse cultural and socioeconomic backgrounds.

The goals of the REU program include 1) Learning scientific concepts and phenomena at the interface of engineering, biology, and medicine, 2) Innovating engineering approaches to lay the foundation for the development of new technologies for medical diagnostics and treatments, 3) Exploring transformative novel engineering applications to solve relevant medical problems that serve humanity in the long term, 4) Applying engineering principles to problems in medicine and human biology while advancing engineering knowledge.

Program Recruitment, Participants, and Programming

The first year of the program had 21 applicants and 7 accepted students. Of the applicants, 8 (38%) identified as man and 13 (62%) identified as woman. 12 applicants were racial minority applicants (black, Hispanic, Asian), 3 did not provide racial identity information, and 6 identified as white. In addition, 11 were first generation students. Of the 8 accepted students, 3 were women, 5 were from underrepresented populations, and 3 were first generation students.

The program activities included mentor programing, student workshops, and cohort building activities. Mentors participated in mentor training at the beginning of the program, weekly check-ins, and final evaluation activities. Student workshops included Point of Care Showcase & Pitch Event, Research Proposal Writing, Communications Workshop, Light in Medicine Training and Workshop, Life of a Scientist, Leveraging your REU Experience workshop, and poster design workshop. Students also participated in cohort building activities such as weekly social events and networking with local startups and industrial partners.

Program Evaluations

Program evaluations consisted of mentor and participant pre- and post- surveys conducted by an external evaluator.

REU Mentor Pre-Post Program Survey Findings

A total of six mentors completed the pre-survey, and five mentors completed the post-survey which focused on mentoring skill development such as: communication, providing constructive feedback, setting expectations, estimating mentee's abilities, and motivating mentees. When the overall means for mentoring skill items are combined, the results indicate that the mentors considered themselves to be *proficient* in their mentoring skills before the program (pre-M = 3.53, pre-SE = .548), and after the program (post-M = 3.69, post-SE = .676). In terms of specific areas, the means for the mentors' mentoring skills *increased* from pre- to post-survey for all areas, except for three items: active listening, establishing a relationship based on trust, and

identifying and accommodating different communication styles, which *decreased* from pre- to post-survey. This could arise from several reasons including initial overconfidence of the mentors on these abilities, exposure to best practices during mentor training which made them realize the gaps in their mentoring abilities, or increased expectations from participating in the program.

REU Student Pre-Post Program Survey Findings

All seven students completed the pre-and post-survey. The pre-post program survey findings for students were:

Research Self-Efficacy*:* The students' self-efficacy survey asked students to rate their abilities on several research related items such as using primary literature, formulating a research hypothesis, designing experiments, collecting and analyzing data, and communicating experimental results. When the overall means for all items related to students' research self-efficacy are combined, the results indicate that the students *agree* that they had abilities to perform the research-related tasks before attending the program (pre-M = 3.69, pre-SE = .282), and their certainty in their abilities *increased in all areas* after attending the program (post-M = 4.34, post-SE = .175). In particular, a notable *increase* occurred in the means for discussing research at a professional meeting or conference. This item had the lowest pre-survey mean (M = 2.86, SE = .459) but had one of the highest post-survey means (M = 4.57. SE = .202).

Post-Graduation Intentions: Both before and after the program, the REU students had *positive* perceptions about going to graduate school which increased after participating in the REU program (pre-M = 3.61, pre-SE = .352; post-M = 4.16, post-SE = .278). In addition, the overall means for students' interest in medical school *slightly decreased* after completing the program (pre-M = 3.29, pre-SE = .374; post-M = 3.06, post-SE = .401).

Students' Perspectives on Performing Poorly on an Exam: Research experiences can teach students to approach failure in different ways. Unlike structured coursework with clear answers, research often involves trial and error, unexpected results, and setbacks that require persistence and adaptability. By participating in the REU program, students can learn to view failure not as a personal shortcoming, but as an opportunity to ask better questions, refine their methods, and deepen their critical thinking skills. In the pre- and post- student survey, we asked students' about their perspectives on actions they would take when performing poorly on an exam. Survey items included items on whether they would perform actions such as evaluating the reasons why it occurred and strategizing next steps. These items *slightly increased* after completing the program (pre-M = 3.80, pre-SE = .184; post-M = 3.98, post-SE = .191).

Research Skills and Knowledge: Overall, students' understanding of research skills and knowledge such as proposal writing, presenting scientific work, research ethics, project management, usage of citations, data analysis, and problem solving *increased* (pre-M = 2.68, post-SE = .206; post-M = 3.88, post-SE = .236).

Leadership and Teamwork Skills: Both before and after the program, students *agreed* that overall, they had leadership and teamwork skills such as working collaboratively, foolwing

instructions, being supportive of others, and training others (pre-M = 3.91, pre-SE = .156; post-M = 4.27, post-SE = .192). The means for leadership and teamwork skills *increased* from pre- to post-survey for all but two items: "I am able to allow other team members to contribute to the task when leading a team" which *stayed the same* and "I know how to cooperate effectively as a member of a team" which *slightly decreased*.

Scientific Identity: Both before and after the program, students *agreed* that they had scientific identities. When the overall means for all items are combined, the means for scientific identity *slightly increased* (pre-M = 3.24, pre-SE = .356; post-M = 3.93, post-SE = .391).

Students' Perspectives on Primary Mentor*:* Students were asked to assess their perceptions of their research mentors including accessibility, approachableness, knowledge areas, providing feedback, and acknowledging contributions. Overall, students *agreed* that they had positive experiences with their mentors (M = 4.23, SE =.344). The item "my mentor was approachable" had the highest mean (M = 4.57, SE = .202).

Students' Perspectives on Overall Experiences*:* Overall, the students were *very satisfied* with the program in general (M = 4.57, SE =.147).

Conclusion

The REU site at UMass Lowell had a strong first year of the program. The seven participating students reported positive experiences, had positive experiences, and formed positive relationships with their faculty mentors. Students' research self-efficacy increased, gained valuable research skills and experience, and had positive perceptions about going to graduate school.

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