

A Three Year Perspective: Effectiveness And Lessons Learned From An Engineering REU Program

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A Three-Year Perspective: Effectiveness And Lessons Learned from An Engineering REU Program

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Research Experiences for Undergraduates (REU's) serve an important role in providing students with an immersive research experience. In many cases REU's provide students considering graduate school with their first research opportunity, can influence them to go to graduate school, and prepare them for success in applying to and completing graduate school. Our REU SITE provided an opportunity for all of these. Our program was a 10-week immersive research experience that supported 10 students per summer and provided strategic professional development to support research success and success in applying to and completing a graduate degree. Here we summarize the outcomes from our three-year award. Each year we have published on different aspects of the project. Here we report outcomes of our objectives from all three cohorts and discuss lessons learned and next steps. The REU SITE program objectives were to 1.) increase the number of historically underrepresented students pursuing a MS or PhD and prepare them for success when applying and completing a graduate degree, 2.) provide an independent scientific research experience in Biomechanics and Mechanobiology (BMMB), 3.) and develop the participants capability to comprehend, contribute to, and communicate about advances in BMMB¹. To evaluate the effectiveness of the program we conducted pre- and post-survey's using the Qualtrics online survey instrument. The statistical analyses were conducted and charts created using GraphPad Prism 9.5.1 software. Over the course of our program, we were successful at increasing the diversity of students pursuing an advanced degree in engineering and BMMB. Of the thirty participants 83% identified as underrepresented minority (URM) and 67% identified as female. Ninety percent of our first cohort and 67% of the second cohort that have graduated have completed or is completing a graduate degree in engineering or BMMB. Of those who have enrolled or graduated from graduate school 83% were URM and 67% were female, thus contributing to the diversity of engineering. Moreover, students felt the SITE REU prepared them for success when applying to and completing a graduate degree $p < 0.05$ and $p < 0.05$ respectively. Additionally, students felt prepared to participate in the basic activities of successful graduate students. Specifically, they felt prepared to write an abstract, prepare and give research presentations, and find and read research papers $p < 0.05$ for each. Similarly, students felt better prepared to participant in independent research $p < 0.05$. Lastly, participants felt better prepared to contribute to and communicate about BMMB by the end of the program $p < 0.05$. Over to course of the project we learned something new from each cohort and responded to student feedback. We also learned to expect the unexpected and to adapt to the changing backgrounds, experiences, and preparation of participants, particularly after the pandemic began. We noted the experiences, needs, and perspectives of students shifted as did the steps we took to support them. Going forward we aim to continue tracking and supporting our participants and hope to continue offering what has been a successful program.

Introduction

Research experiences for undergraduates are competitive summer research programs, which as the name implies provides undergraduate students with an opportunity to participate in research at their home or different institution. These experiences serve as opportunities for students to conduct hands on research and earn money, while preparing for or considering a graduate or professional degree. As an added benefit participants may develop a good relationship with their faculty mentors such that the faculty will write a strong letter of recommendation for the participant or even offer them a position in their lab as a graduate student. In some cases, these programs may increase the participation of students historically underrepresented in the program's particular field of study. Increasing representation is challenging given that participation of underrepresented minorities in engineering is well below parity with society. According to NSF's 2021 survey data, nationally, URMs represented only 15% of the graduate student population in science, engineering, and health and 11% in biomedical engineering (BME), despite comprising 33% of the national population^{2,3}. Our program aimed to increase participation of underrepresented groups (including but not limited to women, Pell Grant eligible, African American, Hispanic, and Indigenous students) and prepare them for success when they apply to and complete a graduate degree, provide an immersive research experience in BMMB, and develop the students proficiency to comprehend, contribute to, and communicate about BMMB¹. Here we report on the outcomes of our program aims across all three cohorts.

Materials and Methods

We hosted ten students per cohort for three summers for a 10-week research experience. Students were paired with a faculty mentor based on their area of research interest. Participants were also paired with graduate ambassador from the faculty mentor's research group. Throughout each 10-week REU SITE students engaged in daily research and several professional development activities per week. The program was designed to prepare participants for success in applying to and completing an advanced degree, while introducing them to the graduate student experience.

We used the data from the twenty-nine of the thirty students who completed both pre- and post-surveys over the course of the three summers. Only nine students from the first cohort responded to both. Thus, we only used the data from students who completed both surveys. We did not collect participant names to maintain anonymity. We linked the pre-and post-surveys based on the demographic information requested in both surveys. To assess our outcomes, we asked questions to gauge knowledge of and preparation for various skills or components of the graduate experience and about demographic characteristics. The Qualtrics online survey instrument was used to administer the surveys.

Table 1 displays the questions used to assess participant knowledge of skills involved in and preparation for the application process and graduate school success. Question 1-7 asked participants to rate how prepared they felt with performing each task on a scale of 1 (Not at all) to 5 (High). Question 8 asked participants to rate the degree to which they felt engaged in independent research on a scale of 1 (Not at all) to 5 (High). GraphPad Prism 9.5.1 software was used to create the demographic charts and calculate paired t-tests.

Survey Questions
1. Please rate how prepared you currently feel about applying to graduate school?
2. Please rate how prepared you currently feel about your ability to succeed in graduate school?
3. Please rate how prepared you currently feel about your ability to communicate about research advances in BMMB?
4. Please rate how prepared you currently feel about your ability to contribute to research advances in BMMB?
5. Please rate how prepared you currently feel about your ability to write an abstract?
6. Please rate how prepared you currently feel about your ability to prepare and give research presentations?
7. Please rate how prepared you currently feel about your ability to find and read research papers?
8. Please rate the degree to which you felt engaged in independent research?

Table 1. List of pre- and post- survey questions provided to participants. (Adapted from ¹, ⁴, and ⁵).

Results

To gauge the effectiveness of the program at meeting our aims we analyzed the pre- and post-survey questions listed in Table 1. Overwhelmingly, the data show the REU SITE participants benefited from the program. The data indicate, students felt the program equipped them for success in applying to and completing a graduate degree $p < 0.05$ and $p < 0.05$ respectively (Table 2). Furthermore, students felt prepared to contribute to and communicate about BMMB by the end of the program $p < 0.05$ (Table 2). Students also felt better prepared to engage in activities associated with graduate student success. Specifically, they felt prepared to write an abstract, prepare and give research presentations, and find and read research papers, $p < 0.05$ for each (Table 2). Similarly, students felt better equipped to engage in independent research $p < 0.05$ (Table 2). The participants of the REU SITE program were primarily from underrepresented and female backgrounds, 83% and 67% respectively (Figure 1). Furthermore, 90% of the first cohort and 67% of the second cohort has graduated from or is completing a graduate degree, the majority are completing a PhD. Additionally, 36% of participants were Pell Grant eligible (Figure 1). Lastly, we noted an increase in the reporting of disabilities and mental illness among applicants. Similarly, there were more participants in the program with mental illness or disabilities.

	ASSESSMENT OF AIMS				Mean Diff.	Sig. Diff. ²	N
	Pre		Post				
	Mean	S.D.	Mean	S.D.			
1	2.21	1.26	4.2	0.68	1.99	p<0.05	29
2	2.20	0.73	4.0	0.88	1.8	p<0.05	29
3	2.54	0.8	4.1	0.56	1.56	p<0.05	29
4	2.8	0.72	4.0	0.62	1.2	p<0.05	29
5	3.4	1.23	4.3	0.3	0.9	p<0.05	29
6	2.3	1.2	3.9	0.82	1.6	p<0.05	29
7	2.23	1.16	3.87	0.54	1.64	p<0.05	29
8	3.2	1.12	4.62	0.6	1.42	p<0.05	29

Table 2. The data analyzed from the pre- and/or post- survey, administered to participants. Sig. Diff. means significant difference.

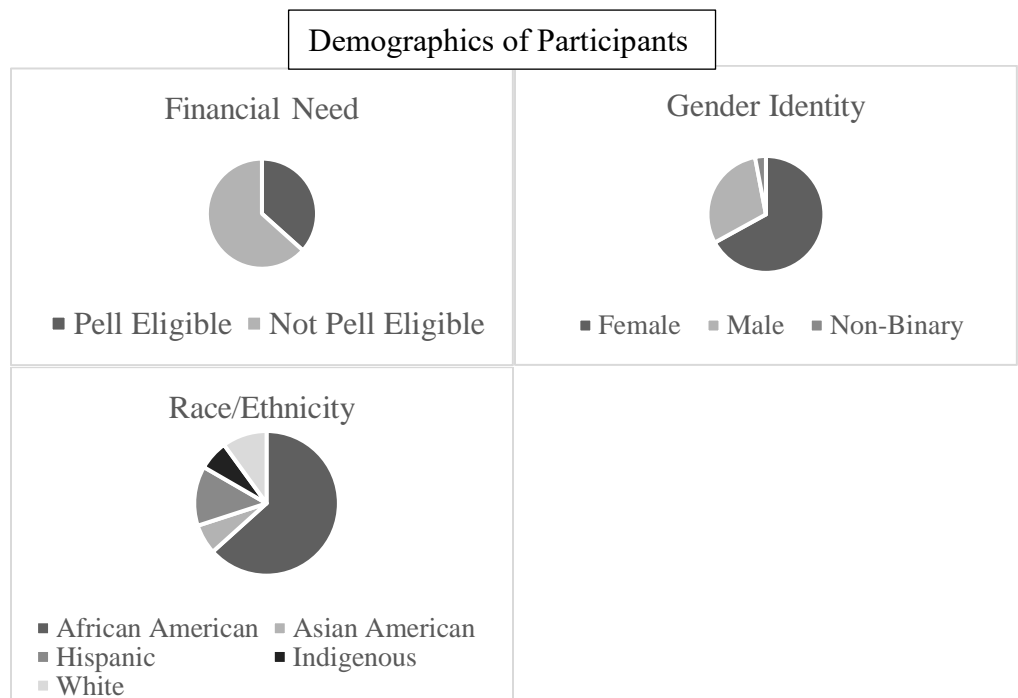


Figure 1. Shows demographic data of the participants.

Conclusion

The data from the three years of our initial REU SITE program indicate we were successful at accomplishing our aims. Moreover, participants believed the program was beneficial and prepared them for success when applying for graduate admission and completing an advanced

degree. Our program also increased access to research for various groups of students including but not limited to Pell eligible students, URMs and women. Despite the marked underrepresentation of students from minoritized backgrounds in engineering, we were able to increase the number of URMs and women pursuing graduate degrees in BMMB. This is a step in the right direction. Over the three years we also adjusted the program based on feedback from students and our observations. For example, we consolidated our bootcamp and adjusted our graduate ambassador training. We will also include the support services we offer to both groups in our planning and onboarding. Going forward, we hope to be able to continue supporting undergraduate student preparation for graduate school and increasing access to an advanced degree.

Future work

We hope to explore the long-term outcomes of this work by continuing to monitor participants through graduation and leverage these findings to support broader STEM efforts to increase access and participation.

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