Work-in-Progress: Preparing the Next Generation of Biomedical Engineering Researchers by Leveraging a Research Experience for Undergraduates

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Abstract

Underrepresented minorities (URM's) and women comprise 30% and 50% of the U.S. population, respectively. In the Biomedical Engineering (BME) discipline they compose 8% and 37% respectively[1]. Thus, the enrollment of these groups is still below their representation in society. The BUCKEYE Research Experience for Undergraduates (REU) SITE program aims to help address this disparity by 1.) increasing the number of traditionally underrepresented students pursing a graduate degree and preparing them for success in the application process and graduate school, 2.) providing hands-on scientific research experience in Biomechanics and Mechanobiology (BMMB), 3.) and developing the participants ability to comprehend, contribute, and communicate advances in BMMB. To do this our students participated in a 10-week research immersion where they participated in research, professional development and social activities. Our cohort consisted of ten participants all of whom were from a traditionally underrepresented background and 70% were female. To assess the outcomes from the program we administered survey's using our site-licensed online survey tool Qualtrics. We used a combination of surveys including pre-and post-surveys to assess program outcomes. Surveys were administered to faculty mentors and participants. The data were analyzed with GraphPad Prism 8.2.1 software using a paired t-test or average. The data indicate that by the end of the program students were conducting independent research $p<0.01$. Overwhelmingly students believed the program prepared them for success in the application process and graduate school, $p<0.04$ and $p<0.02$, respectively. Further, by the end of the program students believed they were better able to communicate about the field of BMMB, $p<0.04$. Seventy-one percent of faculty mentors who responded to the survey indicated their student produced data that could be included in a future publication. Out of the ten participants four are now enrolled in a graduate program, three are currently applying to one of our graduate programs involved in our REU, and another three are not yet ready to graduate. Therefore, the first four students in our cohort to receive their BS degrees are now enrolled in a graduate program contributing to an increase in representation of underrepresented students. We will continue to track whether the remaining students ultimately apply to or enroll in our or another graduate program and the impact of the REU SITE on our graduate program diversity. Moving forward we will modify our approaches to help participants connect the outcomes of their research to their ability to contribute to the field of BMMB, so they are able to identify with the contributions the faculty mentors have noticed.

Introduction

More needs to be done to better position us as a society to address the most challenging issues in the fields of BMMB and BME. Doing so necessitates a diverse cadre of researchers to position us to address current and future engineering challenges. This program aims to address the shortage of URM and women with advance degrees participating in the BMMB field. Nationally, enrollment of URM and female graduate students in BME is 8% and 37%, respectively, compared to the entire field of engineering where URM's and females represent 6.4% and 23% respectively[1]. While enrollment of URM's and women in our Biomedical Engineering (BME) graduate program is 13.6% and 40%, respectively, representation is not at parity with society. In society, URM and women comprise 30% and 50% of the population, respectively. This BUCKEYE REU Site program aims to increase the number of URM's and women pursuing graduate degrees in BME and prepare them for success in the application process and graduate school, provide them with hands on scientific research experience in BMMB, and develop their ability to understand, contribute to and communicate advances in BMMB. To achieve these goals, we have developed a 10-week research immersion embedded with professional development and social activities to recruit and prepare participants for success.

We used a myriad of strategies to recruit students to apply to the REU SITE program. In most cases we contacted students directly using our recruitment database composed of email lists either purchased or obtained through name exchanges and conference attendance. We sent emails to colleagues at targeted institutions to request they share our message with their students. We also sent invites to the Women in Engineering ProActive Network (WEPAN) and the National Association of Multicultural Engineering Program Advocates (NAMEPA) list serves requesting members disseminate our message to their students.

Prior research has shown that many URM students lack knowledge about the admissions process to doctoral programs, have an interest in building social support networks in graduate school and believe faculty are important in recruitment[2]. Another study indicated successful REU programs should address the needs of all the stakeholders and provide meaningful research and communicate what is involved, and provide information about selecting a graduate program, leadership, and a supportive community[3]. Participation in a research experience has been shown to positively influence an undergraduate student's decision to pursue an advanced degree[4]. We completed the first of three research experiences thus far. Here we expand upon current knowledge to show the role of professional development in preparing students for graduate study and research in the field of BMMB.

Each week participants attended professional development seminars focused on topics to facilitate their success in the application process and graduate school, writing a resume and competitive application materials, how to write an abstract and give presentations, and what to expect and how to be successful in graduate school. Throughout the summer students participated in weekly journal clubs with faculty to help them understand faculty mentor research and the discipline of BMMB. Facility tours helped students see firsthand the types of careers available to BMMB researchers. We also assigned each participant to a graduate student research ambassador from their lab to serve as a secondary research mentor. Each week the cohort met with the group of graduate research ambassadors to learn how to give oral presentations and hear firsthand about the graduate student experience. This program placed a

major focus on intentionally identifying ways to prepare students for success in the application process and in graduate school by integrating these professional development activities into their research activities and explaining why and how they related to their overall success as a researcher. We also created multiple opportunities for the students to develop relationships with their peers and build community through a myriad of social events. Social activities were designed to take place during off hours and on weekends to avoid conflicting with student research.

Methods

The mentors identified research project ideas for the participants prior to them arriving on campus. Students participated in professional development opportunities that were either integrated into their research immersion or separate activities. The students participated in these activities multiple times per week including workshops to inform them about how to be successful in the application process and graduate school, ethics, and getting a PhD. Other opportunities included learning to understand and present research with faculty and graduate research ambassadors.

Pre- and post- surveys were developed to assess the program's effectiveness at achieving our goals. The surveys were administered using our site-licensed online survey tool Qualtrics. The participant surveys were administered the week prior to participants arriving on campus and the day before departure following the 10-week research immersion, through two weeks post departure. The faculty mentor survey (post-survey only) was administered the last day of the program and remained open for 2-weeks. Each group was sent at least two reminders to complete the survey. Ten participants completed the pre-survey and nine completed the post-survey. Therefore, we only used the data for nine participants in our analysis. We linked the pre- and post- survey data based on the student responses to the demographic and identifying questions in the beginning of each survey. Seven faculty mentors completed the faculty survey. Table 1. shows an excerpt of the pre- and/or post survey questions asked of faculty mentors and participants. In question 1 faculty mentors were asked to rate the participants on a scale of 1 (Not at all) to 5 (High). For questions 2- 5 participants were asked to rate how prepared they currently felt with doing each of the following on a scale of 1 (Not at all) to 5 (High). The data was analyzed using GraphPad Prism 8.2.1 software using a paired t-test or average.

We maintain contact with our participants in several ways, through email, survey, and communication from the faculty mentor. Through these mechanisms 90% of our participants have responded to provide information about their next steps.

Question	Associated Specific Aim
1. Rate the degree to which your BUCKEYE REU participant was actively engaged in independent research?	Provide opportunities for UGs to conduct hands-on scientific research in BMMB.
2. Please rate how prepared you currently feel about applying to graduate school?	Increase the number of URM students pursing graduate degrees in BME and prepare them for success in the application process and graduate school.
3. Please rate how prepared you currently feel about your ability to succeed in graduate school?	Increase the number of URM students pursing graduate degrees in BME and prepare them for success in the application process and graduate school.
4. Please rate how prepared you currently feel about your ability to communicate about research advances in BMMB?	Develop UGs ability to comprehend, contribute and communicate advances in BMMB.
5. Please rate how prepared you currently feel about your ability to contribute to research advances in BMMB?	Develop UGs ability to comprehend, contribute and communicate advances in BMMB.

Table 1. Shows an excerpt of the pre- and/or post- survey questions asked of faculty mentors and participants.

Results

The faculty worked with their participants for 10-weeks and were able to assess the independent research development of their student throughout the summer. The mentors indicated that students were engaged in independent research by the end of the program ($p<0.01$; Table 2 item 1). In fact, eighty-six percent of faculty indicated that their participant meet or exceeded expectations (Figure 1). Seventy-one percent also indicated that their participant produced data that could be used in a future publication (Figure 2). To date one participant has co-authored a publication with their faculty mentor.

	BUCKEYE REU ASSESSMENT OF AIMS				Mean Diff.	Sig. Diff.[2]	N
	Pre		Post				
	Mean	S.D.	Mean	S.D.			
1	2.28	1.38	4.0	.816	1.71	p<0.01	7
2	2.22	.833	3.88	.927	1.66	p<0.04	9
3	2.66	.866	3.77	.666	1.11	p<0.02	9
4	3	1.0	4	0.5	1	p<0.04	9
5	3.3	1.22	4.1	0.3	0.77	p<0.1	9

Table 2: The data analyzed from the pre- and/or post- survey, administered to participants and faculty mentors, which was most relevant to the specific aims. Sig. Diff. means significant difference.

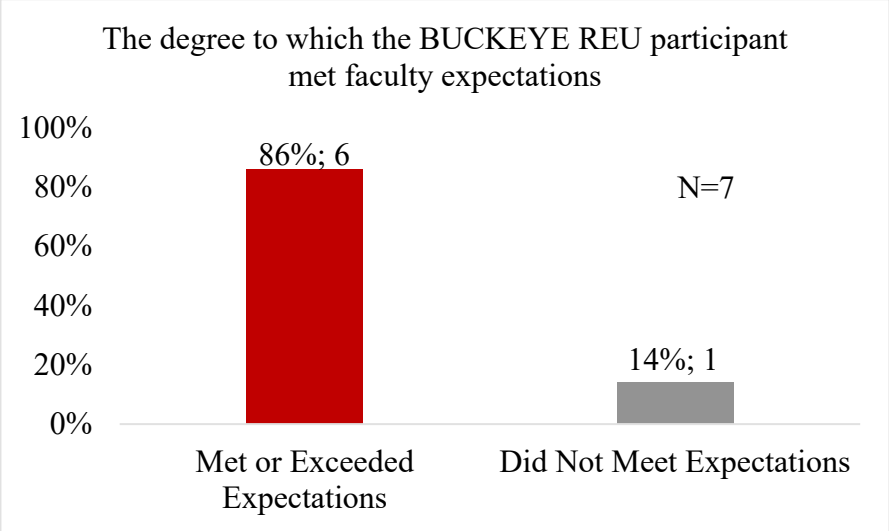

Figure 1. Shows the degree to which participants met or exceeded the expectations of their faculty mentors.

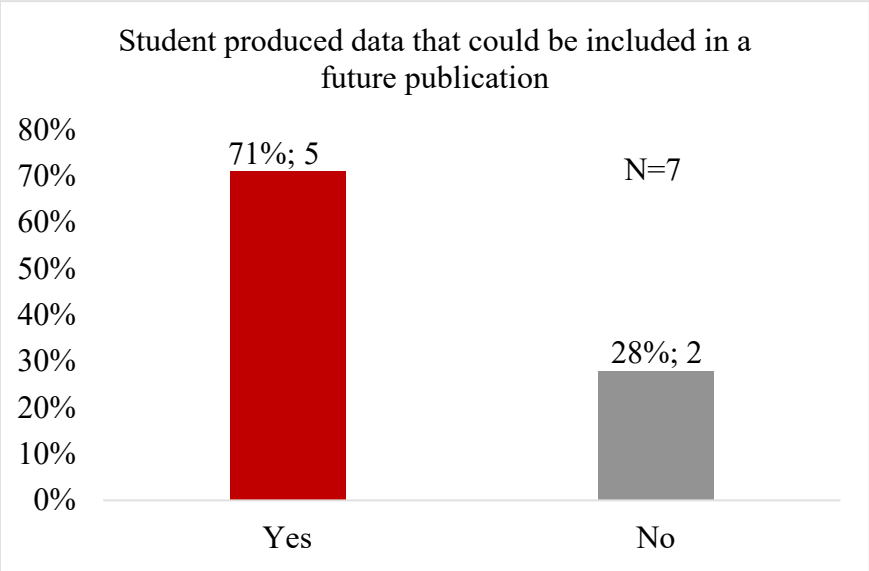

Figure 2. Faculty mentor perceptions of whether students produced data that could be included in a future publication.

The REU SITE included programming to help prepare students for success in the application process and graduate school. The data from questions 2 and 3 on Table 2 indicate that by participating in the program participants felt better prepared for success in the application process and graduate school ($p < 0.04$ and $p < 0.02$, respectively).

The students participated in a journal club together focused on BMMB research being done in their labs and engaged in facility tours of a BMMB industry and clinical research facility. The data from question 4 of Table 2 indicate that by participating in the program participants felt better prepared to communicate about advances in BMMB research ($p < 0.04$). However, students did not believe they were able to contribute to the field of BMMB ($p<0.1$; Question 5, Table 2).

Conclusions

In summary, participants were able to engage in independent hands-on research and according the faculty mentors the data obtained may contribute to future publications. At least one participant has co-authored a publication with their faculty mentor. The immersive research experience combined with professional development activities increased participants perceived preparation for succeeding in the application process and graduate school and their ability to communicate about BMMB. Despite the fact that the majority of faculty mentors believed their student produced data that could be used in future publications most participants did not believe they had the ability to contribute to the field of BMMB. Moving forward we will employ strategies to help participants to better understand how their data can contribute to the field of

BMMB. All the participants in program were URM and 70% were female. Although it is too soon to determine how many of them will ultimately pursue a graduate degree, at least 70% are either currently enrolled in or have been accepted into a graduate program. We will continue to track their decisions over time. The outcomes from this first year are promising and we are hopeful that we can have an impact on the diversity of the discipline of BME and field of BMMB.

Future work

The data presented here represents the first of three summer REU experiences. We plan to modify and improve our program each year based on what we learn from the participants and faculty mentors. We will continue to monitor the impact the program has on the diversity of our and other engineering graduate programs.

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References

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