AC 2009-1647: COMMUNITY-BUILDING ACTIVITIES ENHANCE RESEARCH EXPERIENCE FOR UNDERGRADUATES

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Community-Building Enhances Undergraduate Research Experiences

Abstract

Undergraduate research experiences expand student participation in research as a means of developing a diverse, internationally competitive, and globally-engaged science and engineering workforce. After an undergraduate research experience students should be prepared and motivated to pursue careers in science and engineering. A critical component of an effective program is the cultivation of a positive and supportive community by fostering student-student and student-faculty relationships. The potential benefits of transitioning a summer research experience composed primarily of isolated research and seminars to one based on a learning community approach has recently been demonstrated. In 2008, the Department of Bioengineering at The University of California, San Diego (UCSD) initiated a ten-week summer program through a National Science Foundation (NSF) Research Experience for Undergraduates (REU) site grant in Regenerative Medicine, Multi-Scale Bioengineering, and Systems Biology with an emphasis on community building. The overall objective was to provide to each undergraduate student an intellectually-stimulating and hands-on research experience in a supportive environment by encouraging the formation of a learning community. Achievement of the program's objective was assessed based on the research accomplishments of the participants and through anonymous surveys. Survey results demonstrated that REU participants felt like welcome members of the university and the department and that their experience left them with a positive impression of research. Furthermore, the community-building activities did not detract from their research. Incorporating community-building activities into undergraduate research programs can help provide students with a more meaningful and positive research experience.

Introduction

Despite widespread recognition of the importance of maintaining a well-trained science, technology, engineering, and math (STEM) workforce and significant efforts to recruit and retain students in these fields, the number of students earning engineering undergraduate and advanced degrees in STEM fields in the United States is decreasing. One proven mechanism for encouraging undergraduates to pursue advanced degrees in STEM fields is participation in undergraduate research [3, 4]. The NSF funds a large number of REUs in STEM fields through both site grants and REU supplements. Survey results from over 2,600 engineering REU program participants between 2003 and 2006 showed that overall satisfaction with the program correlate strongly with the amount of time spent with graduate students, post docs, and faculty [3]. Furthermore, common suggestions for improving REU programs included additional training of mentors and increased interaction with other undergraduate researchers and graduate students [3]. While these findings were derived specifically from engineering REU programs they are relevant to undergraduate research programs in general. An earlier study of a wide range of NSF-sponsored undergraduate research opportunities found that being an active participant in the culture of research (i.e. participating because it seemed fun, gaining independence, attending conferences, and understanding the “big picture”) was more strongly correlated with positive outcomes than having successfully completed research proposals, reports, or poster presentations [4]. Taken together, these findings support the assertion that a critical component of an undergraduate research program is the cultivation of a positive and supportive environment by

fostering student-student and student-faculty relationships [1].

One strategy for fostering student-student and student-faculty relationships is through the establishment of a learning community. Learning communities come in diverse forms, for example, a set of linked courses taken concurrently by a small group of students or degree-granting residential programs [5]. While distinctly different, these and other learning communities share a common set of characteristics. Specifically, learning communities strive to develop a group identity, provide facilities and space for community members to engage in learning, provide a supportive environment, integrate social and academic experiences, foster connections between different disciplines, and encourage higher level learning [5]. The potential benefits of transitioning a summer research experience composed primarily of isolated research and seminars to one based on a learning community approach has been recently demonstrated [2].

In 2008, the Department of Bioengineering at the University of California, San Diego (UCSD) initiated a ten-week summer program through an NSF REU site grant in Regenerative Medicine, Multi-Scale Bioengineering, and Systems Biology with an emphasis on community building. The overall objective of the program was to provide to each undergraduate student an intellectually-stimulating and hands-on research experience in a supportive environment by encouraging the formation of a learning community. This paper discusses strategies for establishing a learning community within the context of an undergraduate research program and examines the impact on research achievements and student attitudes toward research.

Methods

The newly established REU program in Regenerative Medicine, Multi-Scale Bioengineering, and Systems Biology at UCSD encouraged the formation of a learning community by promoting positive student-student and student-faculty interactions through mentor training, a graduate advocate, campus-wide activities, networking events within the department, and a REUnion event at BMES.

Mentoring

To help graduate students and postdoctoral researchers improve their mentoring skills and to foster a supportive environment for the undergraduate researchers, a half-day mentoring workshop was held prior to the arrival of the REU participants. All graduate students in the Department of Bioengineering were invited to participate in the workshop and personal invitations were sent to the graduate students and post-doctoral researchers who were directly involved in the REU projects. The workshop included topics and activities selected from *Entering Mentoring: A Seminar to Train a New Generation of Scientist,* a series of eight seminars providing an intellectual framework for mentoring and a forum to discuss and solve mentoring dilemmas [6]. Specifically, the workshop included a discussion of what qualities make a good mentor, examples of mentoring philosophies, motivation for being a good mentor, defining mentor and mentee expectations, elements of a good research project, diversity issues, and strategies for dealing with challenges. Workshop activities included developing a personal mentoring philosophy, defining the mentee's research goals, and sharing personal experiences as a mentor or mentee.

In addition to their research mentors, a graduate advocate was available throughout the summer to provide undergraduate researchers with guidance and support. The motivation for having an advocate in addition to the participants' research mentors was to address problems within the research group and to advise on personal matters that the participant did not want to share with colleagues. The graduate advocate was a 4th year bioengineering doctoral student with extensive experience as a teaching assistant and research mentor and familiarity with the department and university. The advocate was introduced at the start of the program and the participants were instructed to call or e-mail him at any time with personal or professional matters that arose during the program.

Campus-Wide Activities, Seminars, and Workshops

To introduce program participants to other undergraduates and to highlight connections among related disciplines, orientation activities, weekly professional development seminars, and GRE workshops were coordinated among multiple summer programs. As part of orientation, ~70 summer undergraduate researchers gathered at a Challenge Course on campus for an afternoon of team development. The course consists of a series of physical team challenges, including an ascent to the top of a 35 foot climbing tower, that focus on community building, communication, problem solving, leadership, and fun. The same cohort of students attended weekly seminars focused on preparing students to apply to and succeed in graduate school. Seminar topics included: How to Impress a Graduate Admissions Committee (panel discussion), How to Write a Personal Statement, Dinner & Dialogue with a Graduate Student, Keys to Success in Graduate School, Professional Ethics, Effective Scientific Presentations, and How to write a Scientific Paper. Following each one hour seminar there was a group dinner to give students from the different programs an opportunity to meet and discuss the workshop topic in depth. Participants from the same set of programs also attended GRE preparation courses together twice per week for six weeks.

Department Networking Events

Each Friday the program participants gathered for a research skills workshops followed by a professional networking event designed to integrate academic and social experiences, a hallmark of a learning community. The networking events encouraged participants to meet as many current undergraduate students, graduate students, and faculty members in the department as possible. The networking events also provided opportunities to learn more about graduate school and ongoing research in an informal setting. Electronic invitations were sent to guests and REU participants one week in advance to encourage attendance. Examples of networking events include a pizza party with current Bioengineering undergraduates, a smoothie happy hour with current Bioengineering graduate students, and lunch at the faculty club on campus.

REUnion Event at BMES

REU participants were encouraged to submit abstracts to present their research at the Annual Meeting of the BMES during special undergraduate platform and poster sessions. The conference also offered a number of activities specifically targeted to undergraduate students including a resume writing workshop, career fair, and leadership workshop. In addition, many universities hosted evening receptions to meet and recruit future graduate students. Students were encouraged to seek out and talk to investigators whose research influenced their own during the poster sessions and receptions. The UCSD faculty who were in attendance at the meeting and

who served as REU mentors accompanied students to these events and introduced them to colleagues from other institutions.

Assessment

Achievement of the program's objective was measured by the research accomplishments of the participants and through anonymous surveys. Surveys were developed and administered to program participants and graduate student, post-doc, and faculty mentors at the conclusion of the program. Respondents indicated their agreement with statements related to the formation of a community and on the quality of participant work on a scale of 1 to 5, where 1 indicated "strongly disagree" and 5 "strongly agree". Data from these surveys is presented as mean ± standard deviation (SD). Respondents also reported on their activities during the summer and answered open-ended questions. Program participants reported the number of hours they spent on their research project at weekly group meetings as a means of determining if the community-building activities detracted from the research experience.

Results

The emphasis on community-building did not detract from the research effort or quality. Participants spent an average of 39.5 hours per week working directly on their research projects and 76% of that time was spent in the lab. Faculty mentors expressed satisfaction with the participants' performance in the lab with respect to work ethic (4.5±0.6), academic preparation (4.3±0.5), and intellectual ability (4.0±0.8). Eight of the 10 participants presented their research at dedicated undergraduate sessions at the Annual Meeting of the BMES either as a poster or podium presentation. Although nearly all submitted papers are accepted for presentation in the undergraduate sessions, the willingness of faculty mentors to submit the work to a national meeting indicates their satisfaction with the quality of the research. As further evidence of the quality of research, one participant's data was included in a provisional patent application and another participant is preparing a manuscript for a peer-reviewed publication.

Graduate student and post-doctoral mentors indicated through survey responses that the mentoring workshop was valuable, as illustrated by the following comments:

> *"It was helpful to discuss expectations and challenges of being a mentor."*
>
> *"It was useful to go over basic mentoring principles. It was also interesting to hear people's personal experiences."*
>
> *"This was extremely helpful. I have never mentored an undergraduate, so it gave me a good idea of things to be aware of and what to expect."*

All of the graduate student and post-doctoral mentors who responded to the survey reported spending at least 10 hours per week working directly with their mentee and 57% reported spending more than 20 hours per week. Mentors reported engaging in the good mentoring practices discussed during mentor training to various degrees (Table 1).

Mentor Survey Results: Utilization of Good Mentoring Practices	**% Utilized**
Discussed goals and outcomes of your mentee's research project	100%
Discussed expectations of your mentee with him/her	86%

Oriented your mentee to your lab and its practices	86%
Talked with your mentee about things other than research	86%
Discussed career goals with your mentee	86%
Reflected upon your own mentoring philosophy	86%
Discussed amount of time mentee was expected to spend on research	71%
Introduced your mentee to others to expand his/her professional network	71%
Designed your mentee's experiment/project before his/her arrival	57%
Spent time together in an informal setting (i.e. eating lunch together)	57%
Discussed your mentee's expectations of you as a mentor	29%
Discussed mentoring issues with your advisor or other colleague	29%
Considered issues of diversity related to mentoring	14%

Table 1. Percentage of graduate student and post-doctoral mentors who reported engaging in specific good mentoring practices (n=7; 3 mentors did not respond to the survey).

Results from the participant survey indicated that participants were more satisfaction with their graduate student or post-doctoral mentor than with their faculty mentors, although satisfaction with both was generally high (Table 2). Participants felt like a welcome member of the university and the department, the program left them with a positive impression of research, and they all would recommend the program to a friend (Table 2).

Participant Survey Results	**Ave ± SD**
My *grad student and/or post-doc* mentor(s)...	
was available to assist me	4.7 ± 0.7
had a positive impact on my experience	4.7 ± 0.7
My *faculty* mentor...	
Was available to assist me	4.0 ± 1.4
had a positive impact on my experience	3.9 ± 1.5
I felt like a welcome member of INSTITUTION	4.9 ± 0.3
I felt like a welcome member of the Department of DEPARTMENT	4.7 ± 0.7
My experience left me with a positive impression of research	4.8 ± 0.4
I would recommend this program to a friend	5.0 ± 0.0

Table 2. Agreement with statements related the quality of mentoring provided, sense of community, and overall impressions of research and the program. Responses were on a scale of 1 to 5 with 1 indicating "strongly disagree" and 5 "strongly agree" (n=9; 1 participant did not respond to the survey).

Discussion

A learning community approach was used to enhance the experience of undergraduate researchers participating in a new REU site in Regenerative Medicine, Multi-Scale Bioengineering, and Systems Biology. A workshop was held to improve mentoring and ultimately create a more supportive research environment. Professional development activities,

seminars and workshops were coordinated with summer programs in related disciplines as a means of fostering connections between students in different disciplines and to encourage higher levels of learning. Weekly departmental networking events and a reunion at a professional meeting integrated social and academic experiences. The success of these efforts was judged based on the research achievements and attitudes of the program participants.

In general, mentors recognize the importance of making an undergraduate researcher feel as though they are an integral part of the team [3, 7]. Nevertheless, only half of REU participants nationwide are very satisfied with the extent to which they felt they were part of a team, suggesting that mentors do not always integrate students into their research community as intended [3, 7]. While not directly comparable, the participants of this program overwhelmingly indicated that they felt like members of the Department of Bioengineering and UCSD. A more controlled study comparing the attitudes of undergraduates in a research program utilizing a learning community approach to those in programs that do not would help to clarify the effectiveness of specific community-building activities. It would also be of interest determine if the amount of time participants spent with their mentors correlated with their satisfaction with the program, which has been shown for REU programs in general [3].

Participation in the culture of research is strongly correlated with the effectiveness of undergraduate research programs yet, in engineering REU programs nationwide less than 20% of participants have an opportunity to attend a professional meeting [3]. The inclusion of special undergraduate technical sessions at the Annual Meeting of the BMES provided a unique and invaluable opportunity for undergraduate biomedical engineering and bioengineering researchers.

The activities described here may be adapted and incorporated into REU programs or other summer and academic year undergraduate research experiences to encourage the formation of learning communities. The inclusion of community-building activities did not decrease the amount of time participants devoted to research compared to REU participants in programs nationwide but may motivate more students to pursue advanced degrees and careers in science and engineering [3].

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