AC 2012-4995: RESEARCH AND LEADERSHIP EXPERIENCES FOR UNDERGRADUATES (RLEU) IN OPTIMIZATION WITH ENGINEERING APPLICATIONS

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Research and Leadership Experiences for Undergraduates (RLEU) in Optimization with Engineering Applications

Abstract

Traditional Research Experiences for Undergraduates (REU's) typically pair an undergraduate student with a researcher for several weeks. The student's efforts usually result in a poster, a presentation, or even a paper. While these REU's give students a taste of research and some of the technical components of conducting research, technical skills alone are not enough to be successful in a research or academic career. Research experience connected with leadership building experiences will give students a definite advantage as they continue through their graduate and professional careers. This Research and Leadership Experience for Undergraduates (RLEU) grouped a set of minority students on the verge of starting their graduate programs in a project to conduct research in optimization with various engineering applications. The group consisted of students with little to no experience in optimization, students from industrial, mechanical, and civil engineering backgrounds, and students with limited backgrounds within their assigned engineering disciplines. As in traditional REU's, these students were paired with researchers with whom they would conduct research throughout the summer. Unlike more traditional REU's, the students were formed into research teams of at least two students for the same researcher, required to attend optimization lectures, and required to participate in leadership and team building activities. The formation of the small research team gave students the advantage of not entering this process alone. While each student had an individual project, teams had projects that were closely related and on which they could collaborate throughout the summer. This gave students an immediate support group throughout the summer. With a limited background and understanding of optimization, all the students were introduced to optimization concepts and approaches for solving optimization problems together. Since the students were engaged in research, students had the opportunity to connect the lectures to their research and to discuss their research questions with their peers. Most importantly, students participated in leadership activities that required them to evaluate their communication skills, their ability to understand others, their ability to contribute to a group, and their ability to direct a group. The greatest advantage to this RLEU approach is that students gain an understanding of their strengths and weaknesses as leaders and team members so that they can continue to develop in those areas long after the end of the RLEU.

1. Introduction

For over a decade, the number of research experiences for undergraduates (REU) has increased about 70% across STEM disciplines among research institutions, teaching institutions, and community colleges with the aim to increase the number of students seeking to earn graduate degrees.[1, 2] By exposing students to the research setting and to hands on research experiences, students are more likely to pursue graduate careers, have a greater enhancement of important cognitive and personal skills, and have a faculty member play a crucial role in the career decisions.[3,4] In fact, Seymour et al. (2003)

reported in 2002 that students gain, to different extents, personal skills, professional skills, the ability to think like a scientist, laboratory skills, clarification of career paths, enhanced career and graduate school preparation, and changes in attitude toward learning and working.[5] Another study, students' responses indicated that the personal and professional skills they felt they gained through undergraduate research experiences included skills concerning teamwork, leadership, time management, self-confidence, and interpersonal skills.[4]

While REUs have been quite successful, there are several barriers that might post obstacles for students with regards to participating in a REU. The biggest obstacle for REUs is the lack of student awareness about available programs within their own institutions and other institutions.[6, 7] The second largest obstacle for students is poor timing or finding out too late about these opportunities during their academic career for them to apply or participate in the REU.[6] The third largest obstacle is the lack of publicity for the research conducted during the REU, which could be a negative to student self-confidence.[6] The research level expected from students could be higher than the student's abilities or much lower than the student's ability. Either situation could create a negative experience for a student. In fact, some REUs have even changed their focus from being strictly research oriented to being student focused.[7]

Overall, students that participate in a REU have positive experiences that increase their consideration of the pursing a graduate degree or a career in research. However, students have indicated that the important aspects of a REU for them include

- Learning a topic in depth or having intensive exposure to a topic
- The ability to apply their knowledge to a real situation
- Learn to use appropriate methodology
- Learn to work and think independently
- Learn to design solutions to problems and learn to analyze data
- Improving their oral skills
- Improving their written skills
- Clarifying their career plans [8]

2. Traditional/Conventional Research Experience for Undergraduates

The conventional model for an REU consists of assigning two or more students to a faculty advisor and periodically gathering all the REU participants for updates. The student typically meets with their faculty advisor on a weekly basis. The rest of the week the student is typically working along side of a graduate student or on their own. This type of format allows the REU student or "newcomer" to be welcomed into an existing group where the existing members or "old timers" support the newcomer and help with their adjustment into a research environment or their professional socialization. [9, 10]

The REU student will typically have one other REU student in their assigned laboratory, working on a related project. This creates a micro-support group for the REU students as they complete their daily activities. These typical components of a traditional REU have made them such a positive experience for students.

3. Leadership Research Experience for Undergraduates

Our Leadership Research Experience for Undergraduates (LREU) retains the key components of a traditional REU while increasing the extent to which students can have exposure to a topic, opportunities to increase their communication skills, opportunities to increase their team skills, and opportunities to disseminate their research in a professional setting.

3.1 Components of the LREU

One of the major differences between the LREU and a traditional REU is that the LREU students meet each day for at least one hour. This meeting time is generally scheduled for the morning each day. It is within this meeting time, the LREU students participated in activities directly focused on building their communication skills, their team skills, and general knowledge about optimization.

3.2 Additional Support and Learning Group

While many programs periodically gather the REU students from all the laboratories participating in their program for updates, these gatherings do not insure that the REU students bond as a group in the typical summer timeframe. The daily meeting of the LREU students helps to insure that students have time to bond as a group, a group which serves as a support group during their research that is outside of their assigned laboratory.

In fact, due to the limited knowledge and background students have concerning optimization, this LREU group serves as a learning group where students are presented with a brief introduction to optimization concepts and approaches that are directly related to their summer research. RLEU faculty or current graduate students typically present these lectures. Including faculty within this support/learning group gives students additional mentors they can approach for technical and professional clarification.

3.3 Communication Skills

Students have responded that they would like to increase the extent to which they are able to improve their communication skills during the research experience. For this reason, the LREU includes activities that challenge students and their preconceptions of effective communication such as, *Build a Bridge, Blindfold Order,* and *Minefield*, which they reflect on in a written log.

In *Build a Bridge* students are placed into four groups and placed in four separate rooms. Each group is given a bag of Tinker Toys. Each group must construct a portion of a bridge. The four portions of the bridge must fit together to form a bridge. Each group has four opportunities to send a team member to speak with a representative of the other groups. However, the students are not allowed to mention the color of the pieces involved. In this activity, students are challenged to use their descriptive abilities to overcome this obstacle. This activity focuses on having students reconsider their verbal possibilities to describe somewhat simple ideas before moving onto technical concepts. The activity helps students to reconsider how they communicate technical and research concepts to someone not familiar with their field.

In *Blindfold Order*, students are blindfolded and secretly assigned a number. The students are tasked with putting themselves in order without any verbal communication. This activity demonstrates that we make assumptions about what people can and cannot understand from our chosen form of communication. The fact that the students may not always understand each other during this activity illustrates that assumptions are not always correct. This activity highlights the need to consider how an audience will interpret their work given different levels of familiarity with the topic.

In *Minefield,* students are placed in groups of two. One student is blindfolded, while the order student is tasked with directing their partner through a minefield of objects. The immediate result from their interaction highlights how easily simple tasks can be misinterpreted or not carried out correctly. It demonstrates that even simple communication can pose problems to a process.

The students are further pushed to improve their communication skills via the use of weekly reflections of the activities from the LREU group meeting times, various reading assignments, and self-reflection.

3.4 Teamwork Skills

The activities mentioned above also lend themselves to serve as team building activities for the RLEU students. Given the activities require students to be placed into teams, either with or without an assigned role to play within the group, students might rely on their natural tendencies to lead, follow, and contribute or are forced into a position of leadership. After the activities, students must consider their natural leadership tendencies are and their ability to work in a group. This helps to highlight their personal strengths and weaknesses. This experience also gives them opportunities to expand their leadership comfort zone over the course of the program.

3.5 Dissemination Opportunities

While some REUs depend on the individual faculty advisor to find opportunities for students to practice oral communication and for public dissemination of the research conducted, the LREU approach insures that each student has opportunities for practicing oral communication and for public dissemination of their research on a weekly basis for the LREU group. By providing this weekly opportunity, students have a relatively safe environment among their peers to practice. All this practice leads to a poster session that is attended by the faculty of the Industrial Engineering Department, the Mechanical Engineering Department, and the Civil Engineering Department, that is open to the general student body, and that will be posted on the project's website.

4. Conclusions

The additional components of the LREU make a marked differenced for the students in the REU. One clear example of students seeking these additional components comes from an incident, which occurred when this LREU was first presented. This LREU ran during the same period as two other REUs ran on the same campus. REU participants from the other programs asked if they could participate in the LREU group activities if permitted by time, space, and resources. The inclusion of some of these additional

components to existing REU programs could prove to be beneficial to any STEM field seeking to encourage students to enter and success in graduate school.

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References

1. Lopatto, David. "Undergraduate Research Experience Support Science Career Decisions and Active Learning" Life Sciences Education, Vol. 6, pp. 297-306.
2. Hu, Shouping, Kuh, George D., and Gayles, Joy G., "Engaging Undergraduate Students in Research Activities: Are Research Universities Doing a Better Job?" Innovative Higher Education, Vol. 32, pp.167-177
3. Zydney, Andrew L., Bennett, Joan S., Shahid, Abdus, and Bauer, Karen W., "Impact of Undergraduate Research Experience in Engineering" Journal of Engineering Education, April 2002, pp. 151-157
4. Landrum, R.E., and Nelsen, Lisa R., " The Undergraduate Research: An Analysis of the Benefits" Teaching of Psychology, Vol. 29, No. 1, pp. 15-19
5. Seymour, E., Hunter, A.B., Laursen, S.L., and Deantoni, T. (2003) "Establishing the benefits of Research Experiences for Undergraduates in the Sciences: First Findings from a Three-year Study" Science Education, Vol. 88, pp. 493-534
6. Wayment, Heidi A., and Dickson, K.L., "Increasing Student Participation in Undergraduate Research Benefits students, Faculty, and Department" Teaching of Psychology, Vol. 35, pp. 194-197
7. Padmanabhan, G., Davis, Carol, "Undergraduate Research Experience: A Collaborative Model for Tribal Community College Students", American Society for Engineering Education, 2008,
8. Lpatto, David, "The Essential Features of Undergraduate Research", Council on Undergraduate Research Quarterly, March 2003, pp. 139-142
9. Hunter, A.B., Laursen, S.L., and Seymour, E., "Becoming a Scientist: The Role of Undergraduate Research in Students' Cognitive, Personal, and Professional Development" Science Education, Vol. 91, pp. 36-74
10. Russell, Susan H., Hancock, Mary P., and McCullough, James, "Benefits of Undergraduate Research Experiences", Science, Vol. 316, pp. 548-549