

Research Experiences for Undergraduates to Encourage Graduate Studies

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Abstract

The College of Engineering at Rowan University has been hosting an NSF funded REU since 2001. The REU theme is titled Pollution Prevention and Sustainability. The project provides eleven undergraduates recruited from all over the USA to be mentored by faculty on a research project. REU activities are designed to stimulate students' interests in open-ended challenging engineering and science projects, which are mainly related to pollution prevention for a sustainable world. Key program features of the REU include individual research activities, strengthening of communication, leadership and social skills, educational fieldtrips and seminars. Research experiences expose undergraduate students to the creativity of the research process and enable them to apply their acquired knowledge from formal coursework. Active research experience is considered one of the most effective ways to attract talented undergraduates to and retain them in careers in science and engineering, including careers in teaching. Involving undergraduates in research also encourages them to pursue graduate education. This paper focuses on the impact of the REU in encouraging students to pursue graduate school.

Introduction

The National Science Foundation (NSF) funds a large number of research opportunities for undergraduate students through its REU Sites program. REU stands for Research Experiences for Undergraduates. An REU Site consists of a group of ten or so undergraduates who work in the research programs of a host institution. Each student is associated with a specific research project, where he/she works closely with the faculty and other researchers. Students are granted stipends, assistance with housing and travel expenses. Undergraduate students supported with NSF funds must be citizens or permanent residents of the United States or its possessions. The major objectives of the REU program are

- *Generating excitement among the undergraduate students by providing them with the opportunity to work on engineering issues of national and international significance,*

- *Providing* undergraduate students with the opportunity to work on research projects that expose them to graduate students and graduate research,
- *Increasing* the participation in research of women, underrepresented minorities, and persons with disabilities,
- *Mentoring* undergraduate students by providing leadership roles by faculty and students,
- *Exposing* a broad and interdisciplinary group of undergraduate students to the scientific method used in creation, investigation, and documentation of a research project, and
- *Encouraging* undergraduates (especially those from underrepresented groups) to **pursue advanced degrees**.

The Rowan University College of Engineering has a brand new engineering building, including state-of-the-art equipment and computer resources, and a dedicated and extremely competent faculty. Facilities such as seminar and lecture rooms, laboratories, computer rooms, audiovisual equipment and study hall space are located in Rowan University's state-of-the-art \$28M Henry M. Rowan Hall. This newly constructed home of the college of engineering has a 92,500 sq. ft. space with multifunctional state-of-the-art teaching and research laboratories. Founded in 1923 as Glassboro State Teachers College, Rowan University has evolved into a comprehensive regional state university with six colleges. The College of Engineering was initiated as a result of a major donation in 1992 from the Rowan Foundation (Rowan and Smith, 1995). The engineering faculty use innovative methods of teaching and learning to better prepare students for entry into a rapidly changing and highly competitive marketplace. Key program features include: (a) creating inter- and multi-disciplinary experiences through collaborative laboratories and coursework; (b) stressing total quality management (TQM) as the necessary framework for solving complex problems; (c) incorporating state-of-the-art technologies throughout the curricula; (d) and creating continuous opportunities for technical writing and communication (Jahan et al., 1997; Marchese et al., 1997; Hesketh et al., 1998; Jahan et al., 1998; Newell et al., 1999; Johnson et al., 2001). The College has four engineering programs of Chemical, Civil and Environmental, Electrical and Computer and Mechanical Engineering.

Rowan REU Site (2001-2003)

The College received NSF funding in 2001 to establish a three year REU site focusing on Pollution Prevention. A team of nine engineering faculty from various engineering disciplines participated in this REU. The faculty represented a strong diverse and multidisciplinary team. The grant allowed NSF funding of 7 students and Rowan funding for 2 students every summer with a total of 27 participating over three years. Every non Rowan REU participant was paired with a Rowan undergraduate and graduate student already working on research with REU professors through other funding sources such as industries, local and state government. This teaming helped the REU participants to have easy access to inquiries related to the campus, the campus town, sightseeing and laboratory procedures. Students stay on campus for an eight week duration.

Student Recruiting

An average of 80 applications per year were received from students both from science and engineering from all over the country. Recruitment activities included mailings (flyers, letters, emails to chairs, colleagues etc.) to all engineering universities, advertising in student newsletters, selected phone contact/visits, and a web site. The Rowan University REU Website is located at <http://galaxy.rowan.edu/~everett/reu/ReuFrst.htm>.

Fliers were also sent to appropriate professional organizations such as ASCE, the Society of Women Engineers (SWE), Women in Engineering Programs Advocate Network (WEPAN), the National Society of Black Engineers, the Society of Hispanic Professional Engineers, and the American Indian Science and Engineering Society. The Rowan University Educational Opportunity Fund/Minority Achievement Program (EOF/MAP) also assisted in recruitment activities by identifying institutions with a high minority enrollment. Participant selection was based on academic performance, recommendations, and research interests and goals. All application and recommendation forms were also posted on the website for easy access from the start of the REU. In 2003 we also posted an online application form on our website. *It was interesting to note that we consistently received more applications from female students. Informal discussions indicated that the theme of Pollution Prevention appealed to them and the fact that the REU had a number of female role models was encouraging. Three qualified Native American undergraduates were offered REU positions. However all were reluctant to move far from their hometowns.* Our REU was successful in attracting not only a diverse student body from reputable universities but also students from science and engineering from far away states such as California, New Mexico and Oklahoma. Participant data on gender and ethnicity are presented in Figures 1 (a) and 1 (b).

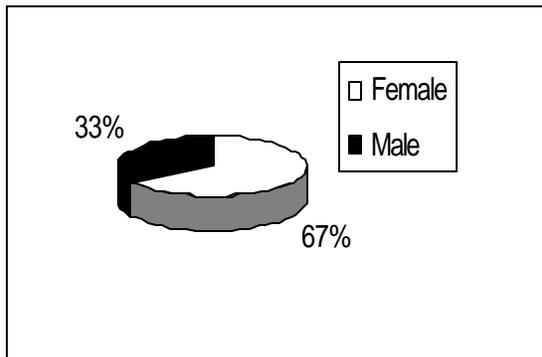
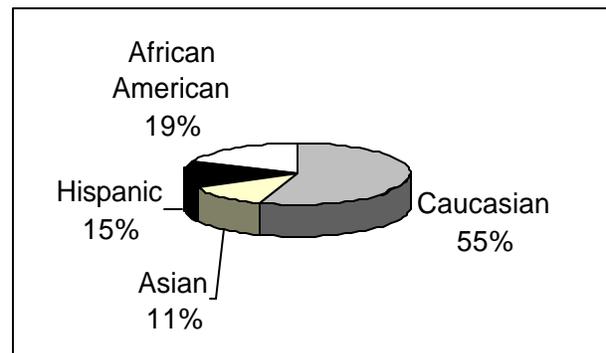


Figure 1: (a) Participant Gender Data



(b) Participant Ethnicity Data

Participating schools over the last three years are shown in Table 1. Applications were received from universities all over the USA from both near and far. Recruitment focused on having a diverse talented student body from all over the country. Selection also focused on students that did not have research opportunities at their own institutions.

Table 1: Participating Schools

2001	2002	2003
University of Rochester	University of Miami	San Jose State University
Virginia Tech, Blacksburg	Wilkes University	Morgan State University (2 students)
Cornell University	Rowan University (2 students)	Rowan University (2 students)
Villanova University	Villanova University	University of Rochester
Rutgers University	Virginia Tech, Blacksburg	New Mexico State University
Rowan University	Rose-Hulman Institute of Technology	Georgia Institute of Technology
Florida State University Tallahassee	Case Western Reserve University	Oklahoma State University Stillwater
Florida Institute of Technology, Melbourne	Illinois Institute of Technology	
University of Wisconsin, Madison		

REU Activities

Participating research faculty offer projects that focus on pollution prevention. Typical titles of projects offered over the REU duration are presented in Table 2.

Table 2: REU Project Titles

Arsenic Removal in Drinking Water
BugPower: Fueling our Future with Microorganisms
Metal Removal from Industrial Wastewater
Developing "Green" Controlled Release Systems for Drug Delivery
Use of Jute in Strengthening Asphalt Mixtures
Stormwater Management in Chestnut Branch Watershed
Environmentally Conscious Disassembly of End-of-Life Computers
Chemical Kinetic Model Development and Flow Reactor Studies of Biodiesel Fuel Blends
Long-Life Smart Structures for Laser Data Transmission
Invertebrates as Bio-indicators of the Water Quality of the Maurice River
Design of Detoxifying Systems for Organo-nitriles Mediated by Cyanogenic Enzymes

Apart from participating in research activities the REU experience also provides opportunities for participants to strengthen their communication skills. Students are required to present their project results both formal oral presentations and in a written report format. Students are encouraged to present their findings at local, state and national conferences and participate in student paper/poster competitions.

Assessment

The outcomes and impact of the REU experience was assessed every year by a designated faculty from the College of Education. Dr. Marianne Cinaglia is currently an Assistant Professor in the Department of Secondary Education. Dr. Cinaglia is extremely active in the planning and implementation of summer science teacher workshops with sponsorship from the Delaware Chapter of the Chemical Manufacturers Association and the Brandywine School District. She is also the chief evaluator and assessor for an NSF funded grant at the College of Engineering (NSF-DUE 9980887). Dr. Cinaglia worked closely with Dr. Jahan in designing and implementing surveys for assessing the success of the REU. Assessment and impact were studied in the following ways:

- a) Surveys (Start, Midpoint and End of the REU) every year for participants
- b) 2 Surveys for past participants to test whether they are still interested in research and graduate school
- c) One annual survey for participating faculty
- d) Student Exit Interviews
- e) Written Student Comments

Surveys were adopted from the University of Oklahoma REU site (Nelson et al., 1998). Pre and post institute surveys were used to gather information on student attitudes about: the place/responsibility of environmental science/engineering science in retaining an acceptable quality of life, research in the environmental science field, research in engineering as a career choice, graduate education in engineering, and effectiveness of mentoring by engineering faculty on career development. Information was also gathered on opinions of the students about the educational and living/recreational facilities at Rowan, the special lectures of the program and suggested changes in the program. A Mid survey was used to ascertain if students were having any particular problems at the time and some information about attitudes on science and engineering in particular. Administered student surveys focused on the students' prior experience with research, expectations for the REU program, role of graduate studies in helping pollution prevention and intentions to pursue graduate studies. The results of the surveys over the three-year period are extremely positive. Participants' perceptions of the quality of mentoring received were assessed through an interview with each student and through completion of a survey at the end of program. Students expressed that they received quality mentoring, perceived the overall climate/environment of the program to be supportive of their individual research efforts and did nothing to deter them from continuing to pursue research related career objectives. During interviews, participants expressed that they received assistance when needed and that professors were generally available and quite willing to discuss research ideas and problems.

Certain questions that indicated the overall quality and success are presented in Table 5.

**Table 5: Mean Responses to Certain Questions Defining Success
(6-point scale 6-strongly agree and 1-strongly disagree)**

	2001	2002	2003
I learned a lot about research methodology.	5.7	5.6	6.0
I will recommend this program to other students	5.8	5.8	6.0
I am interested in attending graduate school to conduct research.	5.5	5.2	5.8
My REU advisor did an excellent job of mentoring during the REU program	5.8	5.7	5.8
I worked with a diverse group of people	5.5	5.8	6.0

Student written comments were extremely positive. Students were extremely impressed with the overall organization and implementation of the REU. Verbatim comments are presented below:

“It was great to learn how your time and research can help the environment and others. Awesome experience.”

“Pollution Prevention is something that everyone should learn. It’s fun, exciting, and rewarding!”

“This experience is something that I will never forget. The lessons that I’ve learned here will last a lifetime.”

“Engineering, Ethics & the Environment- what more could you ask for?”

“Research is something that can’t be taught, it must be experienced”

“I definitely see grad school in my future now.”

“An unforgettable experience”

“The atmosphere was just great. I learned a lot !! Not only about research but about getting along with people I didn’t know”

“An unforgettable summer!! Will come back as a graduate student”

“Ethics are important in your decisions”

“It’s all for the children. You have to think about the children.”

“My REU advisor provided appropriate background information that helped me to understand and prepare my research project.”

“My REU advisor helped to minimize anxieties I had concerning the writing process.”

“My REU advisor did an excellent job!! Made me work hard”

The only weaknesses pointed out included:

- a) Campus accommodation with air-conditioning (This was implemented in years 2002 and 2003 by requesting air-conditioned apartments in Edgewood Hall)

- b) Removal of the one day intense ethics workshop and spreading it over the entire duration (This was addressed by spreading the workshop components in 3 seminars in 2003)
- c) Adding some lighter audio-visual content in addition to the serious ethics video series (This was addressed in 2003 by having movie nights.)
- d) Addition of a field trip to New York (Needs to be implemented)
- e) More time for research activity (Cannot be implemented because of budgetary constraints and housing unavailability on campus for other events held by athletics and the music departments)

Overall Impact

The overall REU success can be measured by looking at stated goals. Our REU was extremely successful in meeting the stated goals. We were successful in attracting a diverse student body that understands the importance of graduate studies. 62% of the students who have graduated are already pursuing graduate studies at prestigious institutions such as University of California, Berkeley, Cornell University, Rowan University, University of Delaware, North Carolina State University, Purdue University, University of Alabama and Pennsylvania State University. The remaining still in school indicate a strong interest in attending graduate studies next year. This information is obtained via post-surveys.

The status of the REU participants is shown in Figure 3 (a). Out of the total of 27 participants over the three years, eleven females and seven males are pursuing graduate school. The ethnicity of the women pursuing graduate school is shown in Figure 3 (b).

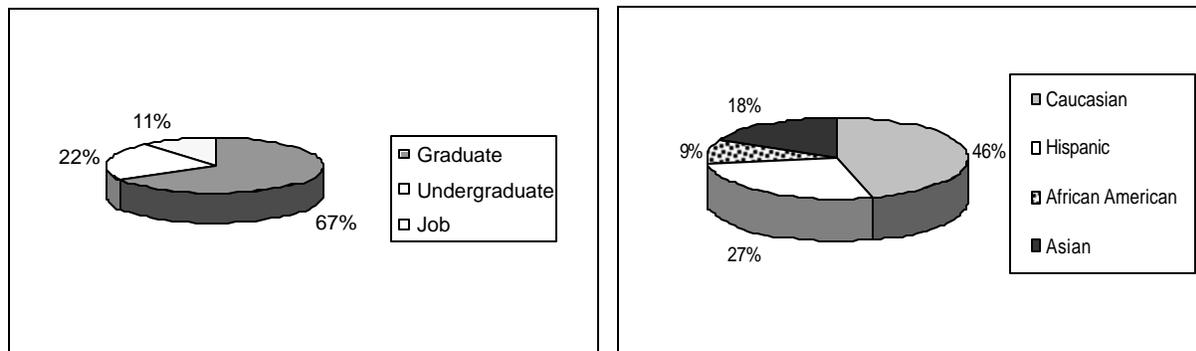


Figure 3:(a) Student Status (b) Breakdown of Female Students Pursuing Graduate School

A large number of these students have been active in publications, podium and poster presentations at technical conferences. Students have also participated at technical conferences and won awards. The REU faculty have also been active in disseminating the REU activities via poster and podium presentations at local, national and international conferences. Overall 35 publications (posters, papers) were generated from this REU. The students have also informed us that their REU experience and publications were instrumental in receiving scholarships and financial aid for graduate school. Our website has also received compliments for being informative. Special links for graduate scholarships, the GRE exams, and minority opportunities have been provided for the convenience of students interested in pursuing graduate studies. The

REU activities were also featured in our local newspapers and the Rowan University website Press Releases. Another successful outcome of the REU is the impact on the non REU Rowan undergraduates who acted as REU buddies. It was noted that out of the 22 students that participated, 14 have graduated and are pursuing graduate studies!! Participating faculty were highly satisfied with the outcomes of the program. Some indicated that they had to spend more time than they originally had envisioned. *However most faculty are participating again in our REU site on Pollution Prevention and Sustainability (2004-2006).*

ROWAN REU SITE (2004-2006)

The College of Engineering and Liberal Arts and Sciences were successful in establishing a new REU site in Pollution Prevention and Sustainability for three consecutive summers. This new initiative is based on an evolving vision of "science and technology for sustainability" that is:

- *anchored* in concerns for human conditions and the environment
- *conservative* of basic life support systems and biodiversity; and
- *integrative* of bridging efforts across the natural, social and engineering sciences, the environment and development communities, multiple sectors of human activity, geographic and temporal scales and, more generally, the worlds of knowledge and action.

Current data from the summer of 2004 are very encouraging with students indicating strong interest in graduate studies.

Conclusions

The Rowan University REU site has been highly successful in attracting a diverse undergraduate student body. REU impact and assessment indicate that undergraduate mentoring via faculty and graduate students can encourage students to pursue graduate studies. The high percentage of women applying for the REU experience is also extremely encouraging. The results indicate that institutions should integrate summer and academic research experiences for undergraduates that help them understand the importance of graduate studies and the workings of graduate school. This will help them have a more diverse graduate student body from the USA and relieve dependence on international students.

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