

## **RESEARCH EXPERIENCES FOR UNDERGRADUATES IN POLLUTION PREVENTION**

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### **ABSTRACT**

A three-year site for Research Experiences for Undergraduates (REU) in the Civil and Environmental Engineering Program at Rowan University has been established through funding from the National Science Foundation and Rowan University. A common theme unifies the Rowan REU Site activities-Pollution Prevention. Site activities focus on fundamental and applied multidisciplinary research in *pollution prevention*. Pollution prevention is a key element of new EPA initiatives to protect our children's health and to promote environmental justice and urban environmental quality. Selected students from all over the USA work closely with engineering faculty on funded research projects in engineering that encourage pollution prevention and sustainable development. This eight-week program exposes students not only to the values of research experiences but helps them reinforce and build other important skills such as communication, social and leadership. The ultimate objective is to provide the REU participants with an enriching research experience that will encourage them to pursue graduate studies.

### **INTRODUCTION**

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. The National Science Foundation (NSF)<sup>1</sup> has established the Research Experiences for Undergraduates (REU) program in its efforts to recruit diverse talented students to engineering and science. A REU site focusing on pollution prevention was established for three years at the College of Engineering at Rowan University starting the summer of 2001. The REU Site at the College of Engineering was established with the following objectives:

- *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 fundamental research projects that have significant impacts on human health and the environment,
- *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,
- *Encouraging* undergraduates (especially those from underrepresented groups) to pursue advanced degrees,
- *Sharing* research with communities outside the university (e.g., industry, pre-college groups which include minorities) through presentations during recruiting efforts and engineering open houses.

### **THE REU SITE**

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. 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. The chemical, electrical and environmental engineering programs have purchased over \$3.4 M worth of equipment in the last four years and have all major analytical equipment for research.

Nine engineering professors are involved in the REU projects, one as Principal Investigator, one as co-principal investigator and the rest as senior personnel. The theme of this REU is such that faculty from various engineering backgrounds can participate. Faculty are actively involved in mentoring activities for students during and after the duration of the REU project. Experienced Rowan Undergraduate Research Assistants, and Rowan Graduate Students work closely with the REU participants.

The REU duration is for 8 weeks, from early June to late July, every year. The funds allow support for nine students. Each participant receives a stipend, room and boarding, meals and travel expenses. Campus housing is provided for the participants.

### **REU RECRUITING AND PARTICIPANT SELECTION**

The College of Engineering at Rowan University supports REU student recruitment activities. Recruitment activities include mailings (flyers, letters, emails to chairs, colleagues etc.) to all engineering universities, advertising in student newsletters, journals and magazines selected phone contact/visits, and a web site. The Rowan University REU Website is located at <http://sun00.rowan.edu/~everett/reu/reu.htm>. Fliers are also sent to appropriate professional organizations and magazines, such as ASCE, the Society of

Women Engineers (SWE), the National Society of Black Engineers, the Society of Hispanic Professional Engineers, the American Indian Science and Engineering Society, Women in Engineering Programs Advocate Network (WEPAN) and SWE. The Rowan University Educational Opportunity Fund/Minority Achievement Program (EOF/MAP) also assists in recruitment activities. Participant selection is based on academic performance, recommendations and research interests and goals.

## **NATURE OF STUDENT ACTIVITIES**

A common theme unifies the Rowan REU Site activities-Pollution Prevention. Pollution Prevention (P2) equates to *source reduction* -- preventing pollution before it is created, so there is less or no need to control, treat, or dispose of it. P2 is also a vehicle for "reinventing" traditional environmental programs and devising innovative alternative strategies to protect public health and the environment. It is a key element of new EPA initiatives to protect our children's health, to promote environmental justice and urban environmental quality, to empower state and tribal programs, to encourage corporate eco-efficiency, to preserve ecosystems and to demonstrate the results and benefits of our labors<sup>2</sup>. Selected students work closely with faculty on current funded research projects in engineering that encourages pollution prevention and sustainable development. Faculty participating in this REU typically actively involved in funded research and in mentoring graduate and undergraduate students. Projects titles offered in the summer of 2001 are outlined below:

- Toxicity of Nonionic Surfactants and Alternatives for Industry
- Innovative Uses of Coal Combustion Products
- Membrane-based Peptide Delivery
- Preventing Non-Point Source Pollution in Semi-Urban Watersheds
- Identifying Performance Parameters for Solar Alternatives
- Pollution Prevention in the Metals Recovery Industry
- Design of Flexible Water/Wastewater Systems for Minimum Discharge
- Development of Optimal Conditions for a Biofuel Cell
- Modeling Biodegradation Kinetics of Nonylphenol

The first week of the REU is spent on orientation activities to help the participants in settling down. Activities include a campus tour with attention to facilities such as the library, recreation center, campus safety office and the dining services, a social picnic at the College of Engineering and an all-day trip to the South Jersey shore. Special attention is given to train students with laboratory orientation and safety procedures. A list of activities during this week is outlined in Table 1.

**Table 1: Schedule for Orientation Week**

Day	Morning		<b>L U N C H</b>	Afternoon	
Saturday	Arrival			Arrival	
Sunday				Picnic at Rowan Hall	
Monday	Orientation Introduction	Dean's Welcome Campus Tour		Pre-Survey	Rowan Hall Tour
Tuesday	Team, Student and Faculty Mentor Assignments			Lecture and Video on Laboratory Safety; Campus Safety	
Wednesday	Field Trip to Jersey Shore			Rowan University Library Tour/ Computer Facilities	
Thursday	Meeting with Faculty Mentor			Introduction to Ethics Component	
Friday	Laboratory Orientation			Discussion of Student Tasks	

For the remaining 7 weeks, students work on their research, under the supervision of the REU professors and graduate research assistants. Students attend formal seminars once a week to broaden their knowledge of contemporary environmental research, issues in engineering education and professional engineering practice. Some seminars focus on issues facing minorities in science and engineering, pursuing graduate school, gender sensitivity, and ethics. Speakers are representatives from local industries, regulatory agencies and other academic research institutions. Each meeting ends with lunch and informal discussions. In week four, Dr. Aarne Vesilind an internationally recognized expert in the area of engineering ethics conducts a daylong ethics workshop. Ethics are intimately related to pollution prevention. The ethics component of the REU is accomplished via readings, discussions between faculty and students, and a daylong workshop. Activities are spread over the entire 8 weeks of the REU (Table 2).

**Table 2: Ethics Activities**

Week	Seminar Description
1	Introduction to Ethics Component, pre-REU evaluation
2	Students complete reading of <u>Engineering, Ethics and Environment</u> <sup>3</sup>
2-3	Students develop Ethical Case Studies
4	Environmental Ethics, discussion of case studies
5	Environmental Ethics (day-long workshop)
6-7	Students work on final essays
8	Submission of final essay, Evaluation of Ethics Component by External Evaluator

Educational and social field trips are used to broaden the knowledge of the participants beyond the laboratory and academic experience. Field trips are expected to include local chemical/manufacturing industries (e.g., Sony, Dupont, Astro Solar, Zeneca Pharmaceuticals) and Wastewater Treatment Plants that have research relevant concerns. Some field trips focus on local tourist attractions such as the beautiful South Jersey Shore, Cape May and the Philadelphia Museum.

Students are required to make presentations to REU faculty and participants on their research progress around the fourth week. A final presentation and a written report is

required. This helps students strengthen their verbal and oral communication skills. On the final Friday, students meet individually with their research professor to discuss their experience and finalize plans for technical publications and presentations. During the first, fifth and last weeks, an outside evaluator (*College of Education, Faculty*) meets with the REU participants to evaluate their experience. The evaluator determines the impact of the REU experience on the participants through written surveys and exit interviews. The evaluator also conducts surveys beyond the duration of the REU to track the students' progress at their respective colleges. The surveys and exit interviews will provide valuable information vital for the improvement of the REU program in subsequent years.

## RESULTS OF REU 2001

Nearly 50 applications were received in the summer of 2001. The nine finalists, 2 males and 7 females reflected a diverse pool from various reputable universities. The participant information is listed in Table 3.

**Table 3: REU Participant Information for Summer of 2001**

<b>Rowan Mentor</b>	<b>REU Student</b>	<b>Major</b>	<b>Institution</b>
Jahan	Female	Environmental	Univ. of Wisconsin, Madison
Everett	Male	Civil	Rowan University
Farrell	Female	Biomedical	University of Rochester
Head	Female	Chemical	Florida Institute of Technology, Melbourne
Hollar	Female	Agricultural	Cornell University, Ithaca
Hesketh	Female	Chemical	Florida State University Tallahassee
Orlins	Male	Civil	Virginia Tech Blacksburg
Ordonez	Female	Civil	Rutgers University
Savelski	Female	Mechanical	Villanova University

These REU participants not only had a Rowan faculty mentor, but were also paired with a Rowan Engineering research assistant. This allowed the participants to become rapidly familiar with the laboratory research environment, the university and the locality. Social activities included a picnic, a South Jersey Fresh Luncheon, trips to the Jersey Shore, Cape May and the Philadelphia Museum. Educational field trips were made to the Sony CD Manufacturing Facility and the Astro Solar facilities. Students presented their research results at a formal closing ceremony and submitted a written report. Some of the REU projects have already resulted in technical publications and presentations awards<sup>4-7</sup>. One of research projects was also awarded a third prize at the Green Engineering Student Poster Competition at the annual AIChE conference held at Reno, Nevada in November 2001.

REU evaluations for assessment were conducted at the start, at the middle and at the end of the program. Students reported the REU experience to be extremely positive, and professionally rewarding. Students indicated that they were extremely impressed with the help and support of the College of Engineering at Rowan University. Students indicated that they were exposed to the values of a research experience and also to research methodologies. Students in the 2001 REU enjoyed the social events and educational field trips. Overall ratings by students were very strong.

## CONCLUSIONS

The REU in Pollution Prevention at Rowan University has been highly successful in its first year. Student recruiting and selection, information dissemination, and assessment results for 2001 are very encouraging. The results indicate the need for such undergraduate research programs for helping students stay focused in school and prepare them for graduate school nationwide.

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## **BIOGRAPHY**

### **Kauser Jahan**

Kauser Jahan is an Associate Professor of Civil and Environmental Engineering at Rowan University, Glassboro, New Jersey. She completed her Ph.D. studies in the Department of Civil and Environmental Engineering at the University of Minnesota, Minneapolis in 1993. Dr. Jahan is a registered Professional Civil Engineer in Nevada and is actively involved in environmental engineering education and outreach for women in engineering. Her research interests include biodegradation of petroleum compounds and surfactant enhanced remediation of slightly soluble organic compounds.

### **Jess W. Everett**

Jess W. Everett is an Associate Professor of Civil and Environmental Engineering in the College of Engineering at Rowan University. He also serves as chair of the Landfilling and Composting committee of the Air and Waste Management Association. Dr. Everett is a registered Professional Civil Engineer in Oklahoma and is actively involved in environmental research and education. Dr. Everett received B.S.E., M.S., and Ph.D degrees in Civil and Environmental Engineering from Duke University in 1984, 1986, and 1991, respectively.

### **Joseph Orlins**

Joseph Orlins is an Assistant Professor of Civil and Environmental Engineering in the College of Engineering at Rowan University. Dr. Orlins is a registered Professional Civil Engineer in Washington and Minnesota and is actively involved in water resources engineering education and research. Dr. Orlins received his B.S.C.E. degree from the University of Washington in 1993, and his M.S. and Ph.D. degrees in Civil Engineering at the University of Minnesota in 1996 and 1999, respectively.

### **Raul Ordonez**

Dr. Ordóñez is an Assistant Professor in the Department of Electrical and Computer Engineering at University of Dayton, Ohio. He has extensive expertise in both theoretical and applied control practice. He has developed and published new control theoretical results in the area of adaptive control algorithms and nonlinear control. He also has significant control implementation experience in laboratory and industrial settings, including work performed on nonlinear estimation, fault detection and fault tolerant control while at GE Aircraft Engines in Cincinnati.

### **Dr. Linda Head**

Dr. Linda Head is an Associate Professor in the Department of Electrical and Computer Engineering at Rowan University. She holds an appointment as a Guest Researcher at the National Institute of Standards and Technology (NIST) in the Semiconductor Electronics Division. Her collaboration with scientists and engineers at has led to improvement in industry standards for accelerated testing of VLSI interconnect

materials and to new techniques for extracting dimensional parameters of the interconnects from electrical measurements. Dr. Head is also the SWE Faculty advisor at Rowan University.

Dr. Kathryn Hollar

Dr. Hollar recently joined the chemical engineering faculty at Rowan University as an Assistant Professor. She received her Ph.D. from Cornell University. Dr. Hollar has been exposed to a wide variety of systems in biochemical engineering, from thermoacidophilic bacteria to plant and animal cell culture, and is interested in applying her expertise to developing methods for cost-effective pharmaceutical production and bioremediation.

Robert P. Hesketh is a Professor of Chemical Engineering at Rowan University. He received his B.S. in 1982 from the University of Illinois and his Ph.D. from the University of Delaware in 1987. After his Ph.D. he conducted research at the University of Cambridge, England. Robert's teaching and research interests are in reaction engineering, freshman engineering, and separations.

Mariano J Savelski is an Assistant Professor of Chemical Engineering at Rowan University. He received his B.S. in 1991 from the University of Buenos Aires, his ME in 1994 from the University of Tulsa and his Ph.D. in 1999 from the University of Oklahoma. His technical research is in the area of process design and optimization with over seven years of industrial experience. His prior academic experience includes two years as Assistant Professor in the Mathematics Department at the University of Buenos Aires, Argentina.

Stephanie Farrell is Associate Professor of Chemical Engineering at Rowan University. She received her B.S. in 1986 from the University of Pennsylvania, her MS in 1992 from Stevens Institute of Technology, and her Ph.D. in 1996 from New Jersey Institute of Technology. Stephanie's has research expertise in the field of drug delivery and controlled release, and she is currently focusing efforts on developing laboratory experiments related to membrane separations, biochemical engineering, and biomedical systems, for all level students at Rowan.

Marianne Cinaglia

Marianne Cinaglia is an Assistant Professor in the Department of Secondary Education/Foundations of Education in the Rowan University. Dr. Cinaglia received a B.S. in Biological Science from Drexel University, and an M. S. in Secondary Education and Ph. D. in Urban Affairs and Public Policy from the University of Delaware. She is actively involved in land use issues on a community level. She is responsible for the evaluation of the Garden City implementation at Rowan. Other evaluation work includes projects at college and precollegiate levels.