

Undergraduate Summer Research in Structural Engineering

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Abstract

For the last five years a summer undergraduate research site in structural engineering, funded by the National Science Foundation (NSF), has operated at the University of Alabama at Birmingham (UAB). During this time 25 students from 18 colleges and universities have participated. Participants are recruited nationally and have come from as far way as California and Puerto Rico. The program is intended to provide students interested in graduate studies with an introduction to research methods, and to provide students who will not continue their studies past a BSCE with a better understanding of how research provides the theoretical foundation of engineering practice. Students work individually with UAB faculty on literature reviews, computer modeling, laboratory testing, and field research. Whenever possible, students work on ongoing projects funded by the National Cooperative Highway Research Program, the University Transportation Center for Alabama, other public agencies, and private industry. Three students have researched structural failure case studies and the technical and ethical lessons to be learned from them. Participants also have the opportunity to tour construction sites and construction material manufacturer's and fabricator's facilities. During the past two years, an ethics seminar series involving a philosophy professor from the UAB Center for the Study of Ethics and Values in the Sciences has been added. At the end of the program students prepare research papers and web pages documenting their work and present their results to faculty, students, and other participants. Many students have continued on to graduate school after completing the program. Significant challenges for faculty include rapidly assessing student research abilities and developing and guiding research projects that can be realistically accomplished in nine weeks.

Introduction

For the last five years, the University of Alabama at Birmingham (UAB) Department of Civil and Environmental Engineering has hosted a Research Experiences for Undergraduates (REU) site in structural engineering, funded by the National Science Foundation (NSF). During this time 25 students from 18 colleges and universities have participated. Participants are recruited nationally and have come from as far way as California and Puerto Rico. The nine-week program is conducted on campus during the summer. Participants must be U.S. citizens or permanent residents.

Students work with UAB structural engineering faculty on projects, generally based on ongoing funded research or on faculty interests, although participants may select their own. Participants are often assisted by UAB graduate students. Participants receive a stipend, and non-UAB students also receive travel expenses, meals, and housing.

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The program is intended both for students who are considering graduate school as well as those who are not. For students considering graduate school, the UAB REU program provides an introduction to research methods and the opportunity to interact individually with faculty and graduate students. It also gives them the chance to experience and overcome the fear, disorientation, doubt, and acceptance that are part of undertaking original research. In some cases, the program has also been instrumental in convincing students that graduate school either was or was not for them. The students that continue on to graduate school have greater confidence, stronger research skills, and in some cases a project that they can continue to work on.

Students who do not go on to graduate school also realize considerable benefit from the program. Throughout their careers, engineers use building codes and design procedures that are the products of research. If they have undertaken their own research, they are in a better position to understand the strengths and limitations of these codes and procedures. It is important for engineers to engage in life-long learning, and this program reinforces this importance and provides a means.

Recruiting

The cornerstone of the program is recruiting students who will benefit from the program, as well as contribute to it. The author mails posters and application forms to faculty at other institutions. Usually about 50 packets are mailed each year, supplemented by personal contacts and phone calls. Students may also apply over the UAB REU web site at http://www.eng.uab.edu/cee/REU_NSF99/reumain.htm. Student transcripts, letters of recommendation, and essays are considered during the application process. However, the author's experience is that these factors are not always good predictors of student success in the program, because applicants rarely have prior experience conducting original research. Often, students with marginal or average academic records do very well in the program.

Selections are made by a committee of UAB structural engineering faculty. The committee emphasizes geographic, ethnic, and gender diversity. It is important to consider students from schools that do not have graduate programs, because these students have few other research opportunities. The summer 1999 participants are shown with the author in figure 1.

Summer Program

Participants arrive in early June. Over the next nine weeks, the students spend 40 hours per week in seminars, on tours, and working on their projects. An initial orientation meeting is held to introduce the participants to faculty, staff, and graduate and undergraduate students. Later in the week, the students begin to meet individually with faculty to start work on their projects.

Because of the short duration of the program, it is important to get students started quickly on their projects. It is important for the faculty to select projects that are achievable within this time frame, but that will also represent a significant accomplishment for the students. Project selection remains a difficult challenge for faculty, but it gets easier with experience. Lists of 1999 and 2000 participants, schools, and projects are provided at the web site listed above.

Research Seminars

A series of seminars provides an introduction to research methods and available resources. The School of Engineering librarian provides an orientation to library facilities and computer searches. Weekly progress meetings are held so that the participants can review progress to date and discuss planned work and potential obstacles. As needed, seminars are scheduled on other topics, such as web pages, PowerPoint, and use of other software packages.



Figure 1: Summer 1999 UAB REU Program Participants

Ethics Seminars

When the UAB REU site was renewed in 1999, an ethics program was added. This program has two components. Each year, one student project concerns ethical issues in structural engineering education and practice and lessons learned from failures. An ethics seminar series is also included. The author is assisted in this seminar series by Dr. Harold Kincaid, a professor in the UAB Department of Philosophy and Director of the Center for the Study of Ethics and Values in the Sciences. Typical ethics seminars include:

- Viewing the film “When Engineering Fails,” narrated by Henry Petroski, followed by a group discussion.
- A discussion of ethical issues in scientific research.
- Small-group discussions of ethics in professional practice, using case studies from the University of Washington Ethics Case of the Month web site (<http://www.engr.washington.edu/~uw-epp/Pepl/Ethics/>).
- Discussion of other case studies, including some prepared by the REU students.

Tours and Field Trips

Since 1999 participants have taken several tours each summer to manufacturing facilities or construction sites. These tours have included:

- Sherman International Corporation precast and prestressed concrete facility in Pelham, Alabama, manufacturing bridge girders (1999).

- Wal-Par, Inc. steel structure manufacturing facility in Birmingham (1999).
- Newmark Infrastructure Solutions prestressed spun concrete pole facility in Tuscaloosa, Alabama (shown in figure 2, 1999).
- Vulcan Materials Company Dulcito Quarry in Birmingham (1999).
- Lehigh Cement manufacturing facility in Leeds, Alabama (2000).
- Human Genetics Building under construction on the UAB campus (2000).
- Butler Manufacturing pre-engineered building manufacturing facility (2000).



Figure 2: Summer 1999 REU students tour Newmark prestressed spun concrete pole facility in Tuscaloosa, Alabama.

Student Publications and Presentations

The presentation of student results is an important aspect of the UAB REU program. Each student prepares a web page, a PowerPoint presentation, and a research paper. The students spend considerable time and effort on these products, which are made available from the UAB REU web site.

Web Pages

The student web pages link from the main REU web page, listed by year. In addition to documenting the student work, these also give students interested in applying for the program an idea of what sort of projects are available. The web pages contain information such as project description and results, link to home university (for non-UAB students), personal information (optional), and research project papers and presentations in Portable Document Format (.pdf) files for download

Final Presentations

All participants make a final presentation to UAB faculty, staff, and students. The two-hour presentation session is scheduled a few days before the end of the program, and lunch is provided. Presentations are limited to ten minutes. Two students from the summer 2000 program making a joint presentation are shown in figure 3.



Figure 3: Sheida Tirado (University of Puerto Rice – Mayaguez) and Michelle Tharp (Tennessee Technological University) present their results, summer 2000.

Proceedings and Student Papers

For the past two years the student research papers have been collected and bound in an annual Proceedings volume. It was necessary to limit student papers to 30 pages, since some wanted to write longer papers. Each student and faculty advisor receives a copy, and a copy is placed in the UAB library.

Other Publications

This program is most valuable for students and faculty in the long term when it produces peer-reviewed publications. Rachel Martin's work in 1999 resulted in two papers published in the American Society of Civil Engineers (ASCE) Journal of Performance of Constructed Facilities (Martin and Delatte, 2000, Martin and Delatte, 2001). Her work was also used in a paper presented at the ASCE 2nd Forensics Congress (Delatte, 2000). Other student work has been incorporated into research reports and publications.

Program Evaluation

Each year participants evaluate the program in order to improve it. The program participants are surveyed on arrival, on departure, and approximately six months after leaving. Survey questions on a five-point scale (1 – low to 5 – high) and 1999 and 2000 results are shown in Table 1 below.

The survey results indicate that the students have strong confidence in their abilities to complete their undergraduate programs. Results on encouraging students to continue on for an MS degree are mixed. In 2000, there was an increase in that tendency, but in 1999 it actually decreased. The desire to continue on for a Ph.D. degree decreased slightly both years. On the other hand, research skills and recognition of their importance goes up significantly, and the understanding of the importance of ethics also increases. From that standpoint the survey results indicate that the program is successful in introducing students to research and ethics and their importance, but less successful in enticing them to continue on to graduate studies. In some cases, the program may serve as a reality check to make them re-evaluate their educational goals.

On departure and on the follow-up survey, additional questions are asked:

- What was the best part of the program?
- What part of program shows the greatest need for improvement?
- What was the best part of the ethics component? The worst?
- What other ethical issues in engineering should the group take up in addition to those we discussed?

Some comments on the best part of the program were:

- One of the best parts of this program is seeing how real research is conducted and reported. Being able to conduct and report research seems to be an invaluable skill. The ethics discussions were also interesting and insightful.
- I think the best part was that for the most part, this project was independent. Although we had an advisor to turn to if I needed help, I didn't feel like someone was constantly looking over my shoulder. I had to plan what I would do, when it needed to be done by, etc. I think independent work on a project is invaluable, for all the things it teaches you.
- I learned that I really enjoy doing research – but more importantly, it revived my interest in structural engineering and helped me pin point specifics in the field.

Table 1. Summer 1999 and 2000 Evaluation Results

Questions	1999		2000	
	Before	After	Before	After
(1) I am capable of completing my undergraduate degree.	5	5	5	5
(2) I intend to complete my undergraduate degree.	5	5	4.875	5
(3) I intend to attempt to complete a Master of Science degree in Structural Engineering or a closely related discipline.	3.375	3.25	3.875	4.625
(4) I intend to attempt to complete a Doctor of Philosophy degree in Structural Engineering or a closely related discipline.	1.5	1.375	3	2.5
(5) Knowing how to conduct, document, and interpret research is important for a practicing engineer.	4.25	4.625	4.625	4.75
(6) I can plan and complete a research project and report the results.	4	4.25	4.25	4.625
(7) I can conduct a thorough literature review of a topic.	3.875	4.5	4	4.75
(8) Research must be conducted ethically.	4.75	4.875	4.625	4.875
(9) Practicing engineers must always maintain high ethical standards.	4.5	5	4.75	4.875
(10) I intend to take the Fundamentals of Engineering exam	4.25	4.5	4.875	4.875
(11) The ethics part of this REU was very useful and important	N/A	4	N/A	3.875

Recommendations for improvement addressed faculty availability and project selection, among other issues. Based on evaluation of the 1999 results, the following changes were made for summer 2000 and future years:

Faculty availability – UAB faculty are on 9 month appointments and spend summers in research or consulting, with limited teaching. As a result, some faculty members were less available than others. Changes to improve faculty availability were to distribute three students to faculty who have enough projects available, rather than automatically placing two with each, and to have more graduate students available to help students.

Project selection – It is challenging to develop a suitable 9-week undergraduate research project, particularly with limited information about participants’ talents and interests. Nevertheless, this is important if the students are going to produce publishable results and achieve the satisfaction of seeing a complicated project

through to completion. To improve project selection, projects and student interests will be classified as laboratory/field, analytical/modeling, or literature review/report to make it easier to find an appropriate match. Also, earlier recruiting will enable faculty advisors to correspond with students about the projects in advance.

Laboratory involvement – Only one of the summer 1999 projects involved extensive laboratory work. Several of the participants indicated that they would have liked to have had more laboratory experiences. To address this concern, more projects were offered in the laboratory/field category.

The six-month follow-up survey of 1999 program participants produced results similar to the exit survey. The 2000 program featured better matching of faculty to students, better project selection, and laboratory and field-testing projects for more than half of the participants. As a result, suggestions from the 2000 program evaluation were primarily administrative. Pairing two students for a labor-intensive laboratory or field project worked well, and this arrangement will be used when appropriate.

Summary and Conclusions

The UAB REU site in Structural Engineering has been highly beneficial for the department and the participants. The student work has enhanced the breadth and depth of research underway at UAB, and has paved the way for expansion into new areas of research for UAB faculty. Survey results have consistently shown that participants consider this a valuable and useful experience. Many of the past program participants have gone on to graduate school at UAB or elsewhere. Three were employed full time as graduate research assistants at UAB during the 2000-2001 academic year. UAB structures faculty have been contacted several times to write graduate school recommendations for former REU participants.

However, the program also requires a considerable investment by the department. NSF funds one and a half months of faculty time and no staff time; remaining costs must be borne by UAB or by other external grants and contracts. Considerable time must also be invested by faculty to get the students started on their projects.

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