UNDERGRADUATE RESEARCH AS A VEHICLE FOR SUCCESS FOR WOMEN IN ENGINEERING

Janet Stocks
Carnegie Mellon University
Pittsburgh, Pennsylvania

Barbara Lazarus
Carnegie Mellon University
Pittsburgh, Pennsylvania

The Undergraduate Research Initiative (URI) at Carnegie Mellon University began in the spring of 1990 with the award of 8 small grants to undergraduates pursuing independent research projects. The program has grown substantially and last year (1998-99) awarded grants to 191 students. The URI has a variety of programs but we will focus in this presentation on two: the Small Undergraduate Research Grant (SURG) program and the Summer Fellowship program.

- The SURG program awards small grants, up to $500, to undergraduates in good academic standing (they cannot be on academic or disciplinary probation) to cover research related expenses. Typically, students apply for funds to pay for materials and supplies necessary to carry out their research. We also occasionally receive requests for funds to cover travel, and sometimes for a stipend so that students can "buy out" student job time. To receive these funds, students must write a research proposal in which they explain their research question, their proposed methodology, their qualifications for carrying out this research, and how they intend to disseminate their research findings. In addition, students must secure a letter of recommendation for their proposed research from a faculty advisor who is willing to oversee their research. These proposals are then reviewed by a committee made up of faculty representing a wide variety of disciplines on campus. In the past several years we have been able to fund approximately 70 - 75% of the proposals submitted to us.
- The Summer Fellowship program awards stipends of $3,000 to students to support ten weeks of full time research during the summer months in close collaboration with a faculty advisor. The process for awarding these fellowships follows the SURG granting process of proposals submitted by students and reviewed by a cross-disciplinary committee of faculty. We have awarded summer fellowships for the past three summers, 8 in the first year, 11 in the second, and 43 in the third. This program is more competitive than the SURG program because we have sufficient funds only to cover the most highly-rated proposals. Last summer we were able to fund approximately 50% of the proposals that were submitted.

Funding for these programs comes from a variety of sources. The University provides the funds to cover our administrative expenses (a full-time director, a full-time assistant and an annual operating budget) and approximately half of the SURG grants we award.

We also receive funds from a variety of foundations, corporations, and individual donors. Many of our fundraising efforts have been targeted to increasing the fund pools to support the research of women students. For example, last year we received a grant from the Intel Foundation to fund summer fellowships for ten women and minority students in engineering and computer science. Many of our other funds are likewise targeted to women. We have a greater proportion of women participating in our programs than are in the campus population overall. For example, last year 43% of the SURG grant recipients and 37% of the Summer Fellowship recipients were women while the campus population was 34% women.

There are a number of aspects of these programs which make them unique among similar programs at other colleges and universities:

- Students are encouraged to propose independent research projects as well as join existing research labs on campus
- Groups as well as individual students can apply for funds
- This is not intended to be a capstone experience.
- Students throughout their college years (not just seniors) are encouraged to participate.
- Students who are struggling academically, as well as those who are excelling are encouraged to participate.
- These programs are intended for students in all disciplines. "Research" is broadly defined to mean: "Research, scholarly, or artistic activities that lead to the production of new knowledge; to increased problem solving capabilities, including design and analysis; to original critical or historical theory and interpretation; or to the production of art or artistic performance."

Although these programs are open to all students on campus, they are particularly beneficial for women and other underrepresented students. Our exit surveys for the undergraduate research experience show that students develop mentoring relationships with faculty members, increase their self confidence, learn about the process of conducting research and solving unstructured problems, and gain a more focused sense of their future. Recent studies, both at Carnegie Mellon and at other undergraduate research programs in the U.S. (e.g. 3), indicate that undergraduates who engage in a substantial research project with a faculty advisor are more "attached" to their institutions and are more likely to "persist" to graduation. This type of experience proves to be particularly important for students who are underrepresented in their academic fields and who, without this support, often feel alone and disenfranchised from the mainstream of their disciplines.

EVALUATION OF OUR PROGRAMS

During the summer of 1999 we conducted an evaluation of our Summer Fellowship program. Funded by a grant from the Intel Foundation, we used both quantitative and qualitative measures to evaluate the impact of a summer research experience on the students. We conducted a pre- and post-survey of four groups of students: 1) women and minority students in engineering 2) majority students in the sciences 3) students who had internships in industry and 4) students who had non-academic summer jobs. The survey

was designed to test self efficacy--students' beliefs about how well they can perform in specific settings. In addition we conducted interviews with all students who received Summer Fellowships at the end of the summer and a survey of their faculty advisors.

Pre- and post-survey

Surveys were administered to four groups of students at the end of the spring semester (before leaving for summer jobs) and at the beginning of the fall semester. The four groups of students were:

- women and minority students in engineering
- majority students in the sciences
- students who had internships in industry and
- students who had non-academic summer jobs

After initial questions asking for background information about the type of summer job the student had, the survey asks a variety of questions intended to measure student self-efficacy (beliefs about how well they can perform in specific settings) such as:

- How well can you use the techniques, skills and modern tools necessary for professional practice in your intended career?
- How well can you converse with professors about topics in your field?
- How well can you successfully interview for a job or internship in your field?
- How well can you participate in discussions of contemporary issues?

Students answered these questions on a seven-point scale from "very well" to "not well at all."

The results of this pre- and post-survey were that students who participated in research (groups 1 and 2) showed increases in self-efficacy scores after their summer research larger than those who participated in a job in industry, who increased more than students with non-academic summer jobs. Because of the small numbers of students in each group, these results were not statistically significant.

Interviews

All students who participated in the summer research fellowship program were interviewed at the end of the summer about their experiences. We have just begun to do the data analysis of these interviews. For this presentation we will focus on the group of ten students who were funded by our Intel grant for women and minority students in engineering and computer science. In this group were 7 women and 3 men. Four of the women are Caucasian, two Asian, and one African American. All three men are Hispanic. We report here on just a few of the interesting findings that are emerging from our qualitative data.

1. Women respondents commented about the contextual nature of the learning experience. Research on women and learning styles (e.g. 1, 2) has shown that many women prefer to learn in a setting where they can clearly see the application of new knowledge to something in the world that they see as worthwhile. In our interviews, we heard this over and over again from our respondents. For example, Heather, a chemical engineering major said about her research, "It's made me realize how my major applies in the real world . . .It made me see how what I'm doing in the

classroom really applies. I think it will help me in my course work and deciding what I want to do. This applies to a class I was frustrated with last semester. Now I feel like I was learning it for a reason and I put in all that work for a reason." And Alice, a computer science major said, "It helped re-spark some of the intellectual curiosity that I had lost in my class work, worrying about my GPA and so forth."

2. The research experience led many of the students to decide they wanted to further their education. Of the ten Intel fellows, seven have decided they want to go on to graduate school, two have decided, based on their experience, that they do not want to go directly to graduate school, and one is still undecided. Kate, a Materials Science major, decided about three weeks into her summer research project that she wanted to go to graduate school. "It's driving me towards grad school because I want to know more and I want to get more specific education in particle research before I just go out and try to peddle my wares to the market." Melanie, a chemical engineering major and engineering and public policy minor, attended a seminar sponsored by our office over the summer about career choices after the BS degree. In her interview she referred to this talk: "she [the seminar speaker] mentioned grad school and I hadn't even considered it. But the more I thought about it, I couldn't get the chance to do straight out policy and engineering research like this unless I go to grad school . . . So that's something to think about."

   Even for the two students whose summer research experience led them to believe that graduate school was not the best option, this appears to us to be a positive outcome because the experience led to an informed decision. For example, Heather, the chemical engineering major quoted above said "It's made me see what it's like to do a research job in a university. I work in a lab with graduate students. I see how their research is. We also have group meetings where the graduate students present their research. It's made me see what a commitment graduate school is and I don't think it is something I want to do right after school. But I know what it would mean to do it if I would decide to go back and do it later."

3. Experiences that students articulated as their "most negative" during their summer research, were, to us, good lessons learned. We asked all students what the most positive and negative things about their summer research experience were. Of the ten interviews we have analyzed to date, only one experience reported was really a negative experience, and this had to do with some scheduling difficulties the student experienced with his advisor. The rest of the students articulated things that had to do with becoming more familiar with the research process. For example, Jan, a Chemical Engineering major said that what was negative was "maybe just the repetition. I hadn't really realized how repetitive some of the work was. Overall through, it has been a very positive experience." Kate (the computer science student quoted above) said, "In the beginning [of the summer] it was kind of confusing for me to figure out how to impose a structure upon myself when there was no class structure or deadlines outside of my own. That was a stumbling block in the beginning, but then I figured out what I needed to overcome those things." And finally, Mary, a psychology major, said "I think I am a little disappointed that I don't have more time to work this summer because I've gotten so into it. Fortunately, I will get to keep doing it during the school year."

Faculty Surveys

We sent a short e-mail survey to the faculty advisors of all of our summer fellowship students at the end of the summer. We received completed surveys from 32 advisors of the 41 students who completed their fellowships (a 78% response rate). On the whole, advisors were very pleased with the work done by the undergraduates and 100% of the faculty respondents said that they would be willing to advise a summer fellowship student in the future. Only two faculty advisors reported that the quality of their student's work was less than they had expected. Fifteen (47%) reported that the quality was better than they had expected, and fifteen (47%) reported it was about what they had expected. Nineteen faculty advisors (59%) reported that the work done was above average for an undergraduate student, and five (16%) said that the work done was what they would expect from a graduate student. Twenty-eight of the 32 faculty respondents (88%) felt that the students had grown from their summer research experience. For example, one advisor said "Going to the conference and presenting her work has given Alice a very palpable excitement about the field of robotics and academia." Another faculty advisor said, "During the summer, Heather became more independent and confident about her research. As a sophomore, she has had limited laboratory experience and little practice at independent work. I sensed her gaining confidence in her laboratory skills during the summer."

CONCLUSIONS

Undergraduate research provides opportunities for women in engineering to engage in the important and exciting work of creating new knowledge. In doing so they find mentors, imagine themselves in research and academic careers, and refine career goals. We believe that these kinds of experiences can be beneficial for all students, but they are particularly beneficial for women and other students who are underrepresented in their fields. This is because it helps these students find practical, hands-on applications of the sometimes abstract knowledge they are learning in the classroom, and helps them imagine themselves as contributing members of a research community.

We were particularly intrigued by the results of our faculty survey. Specifically, all faculty responding to the survey when asked if they would participate in this program again, said they would. These results are exciting in an environment where service to undergraduates is often perceived as a drain on time and "real work". Although we recognize that the faculty who participate in the program are self selected, we nevertheless tentatively hypothesize that faculty involved in this kind of program may change their view of undergraduates as researchers/potential colleagues and that those who work with women and students of color may similarly change their perspectives. We plan to add these questions to our research agenda in the future.

REFERENCES

1 Gilligan, Carol, 1982. *In a Different Voice: Psychological Theory and Women's Development.* Cambridge Massachusetts: Harvard University Press.

2 Margolis, Jane, Allan Fisher and Faye Miller, 1999. *Computing for a Purpose: Gender and Attachment to Computer Science.* Working paper of the Carnegie Mellon Project on Gender and Computer Science (http://www.cs.cmu.edu/~gendergap).

3 Nagda, Biren A., Sandra R. Gregerman, John Jonides, William von Hippel, and Jennifer S. Lerner, 1998, "Undergraduate Student-Faculty Research Partnerships Affect Student Retention" in *The Review of Higher Education*, Volume 22, No. 1, pp. 55-72.