

Increasing the Number of Minority and Women Engineering Students Obtaining a Graduate Degree

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Abstract--The Collaborative Interdisciplinary Research Community (CIRC) program in the Ira A. Fulton School of Engineering at Arizona State University has as its goal increasing the numbers of both women and underrepresented minority students pursuing an advanced degree in engineering. Students in this program maintain at least a 3.0 GPA and are therefore eligible for graduate school. They also have financial need and therefore the program scholarship reduces the number of hours that these students must work to stay in school. CIRC is part of the Computer Science, Engineering, and Mathematics (CSEMS) program funded by the National Science Foundation to encourage the completion of undergraduate engineering degrees and the acquisition of advanced degrees, especially by women and underrepresented minority students. Nationally, due to the low percentages of women and underrepresented minority students earning advanced degrees in engineering, extra efforts are needed to educate these students about the benefits of an advanced engineering degree to enhance their career options so they can make an informed choice. The degrees and requirements of graduate school are addressed during the five workshops per semester for CIRC students. The students are encouraged to apply for research positions and internships. A panel of graduate students gives the CIRC students a better picture of what graduate school is really like. Engineers in industry with advanced degrees are brought to campus to tell the CIRC Scholars how their advanced degree has benefited them and of the need by industry to hire more engineers with advanced degrees. This paper will focus on how students have overcome obstacles to attend graduate school. Obstacles include: finances, the belief that there are few jobs for advanced degree engineers, the belief that graduate school is much harder than undergraduate, and the belief that it is better to get a graduate degree later. The paper will give examples of students in the CIRC program who were inspired through the workshops by other students and engineers who overcame obstacles to graduate school, and have, as a result, decided to attend graduate school themselves after graduation.

I. Introduction

It is well known that the number and percentage of U.S. citizens and permanent residents receiving graduate degrees in engineering has been decreasing. Nationally, over 50% of the engineering master's and doctorate degrees are awarded to foreign nationals (Engineering Workforce Commission, 2004). In order to remain competitive in the global marketplace, research done by engineers and computer scientists in industry is more important now than ever. The U.S. workforce in science and engineering totals 4.7 million, of which 2.5 million are classified as having engineering jobs according to the National Science Foundation. Only forty-eight percent of these workers have bachelor's degree, 22 percent have master's, 7 percent have

earned doctorates, and 2 percent professional degrees. Most of those without a four-year degree, 492,900, work in engineering (Prism, January 2005.). The percentages of women and underrepresented minorities receiving engineering graduate degrees each year is very low. In 2004, only 22% of the master's degrees and 17.5% of the doctorate degrees in engineering were earned by women. Only 5% of the master's degrees and 3% of the doctorate degrees in engineering were earned by underrepresented minorities (African American, Hispanic, and Native American) (Engineering Workforce Commission, 2004). This low number of women and minority engineers with advanced degrees impacts our country's global economy. In addition, many engineering professors are expected to retire in this decade and so more engineering professors are needed to fill these vacancies (Bowen & Schuster, 1986). The percent of women engineering faculty is only 9.9% and the percent of minority faculty is even less, 5.6% (ASEE, 2004). With so few women and minorities earning doctorate degrees in engineering, these percentages will not change much in the near future. The first step toward increasing these numbers in academia and industry is to get more women and underrepresented minority students into engineering graduate school. Often engineering students do not consider becoming a faculty member until they are in graduate school.

The CSEMS (Computer Science, Engineering, Mathematics, and Science) Program was designed by the National Science Foundation to help remedy the lack of U.S. citizens and permanent residents receiving graduate degrees in these four disciplines. The program allows up to a \$3,125 stipend per year for qualified students, with a special concern for women and underrepresented minority students. The Ira A. Fulton School of Engineering at Arizona State University (ASU) was awarded a CSEMS grant for five years beginning in the fall of 2002. The ASU program is called CIRC (Collaborative Interdisciplinary Research Community) (Anderson-Rowland & Johnson, 2004a).

II. The Challenge of Encouraging Students to Attend Graduate School

To go to graduate school is a difficult decision for most students, especially women and minority students (Lazarus, 2001, Owens, 2004). Why don't more engineering students continue on to graduate school? To attend graduate school, a student must have a good academic record and often the finances to support themselves. The CIRC students are all good students academically and all have financial need. The qualifications for admission to the CIRC program are:

- U.S. citizen or permanent resident
- Engineering or Computer Science major
- Demonstrated financial need based on FAFSA
- Minimum 3.0 GPA
- Enrolled as a full-time student (minimum 12 hours)
- Personal essay on academic plan
- Two letters of recommendation, at least one from a faculty member

We have found that these students, in general:

- Have never considered graduate school
- Have little or no idea of what graduate school is like
- Have little or no idea about the choice of an M.S. or M.S.E. degree
- Are not aware that they can apply directly for a Ph.D. degree

- Do not know what they should look for in a graduate school nor how they can get the information
- Have little or no idea of what research is or how to obtain a research position
- Do not know money is available to finance graduate work or how to obtain this support
- Work and want to graduate and to earn good money as soon as possible
- Believe that a graduate degree will diminish their chances of obtaining a position in industry
- Believe that they will lose money in the long run by not starting to work right away with a Bachelor's degree
- Believe that graduate school is like undergraduate school, only much more difficult
- Believe that the only advanced degree worth getting is an MBA
- Do not understand that an advanced degree can allow them to do more interesting and challenging work in industry
- May possibly consider an academic career after they learn more about graduate school

The goal of the program is to make sure that the students graduate and that they consider graduate school. To help ensure that they graduate, the students are given information on time management and the program directors are a resource for the students when they have problems. Since many of the students have never considered graduate school (no one has ever talked to them about it), several workshops each year are devoted to basic graduate school information about the choices available for degree programs, what to look for in a graduate program, and how to get involved in research or an internship as an undergraduate. This information is given by the program directors, panels of graduate students, and also engineers in industry with advanced degrees.

One of the homework assignments for the CIRC students is to study the research that is being done at our School, to select a professor whose research interests them, to talk to the professor, and to inquire about a research position or volunteer for one. Several of the students in the program have received research positions through this method. Once in a research arena, the students are aware of a whole different side of academics and begin to understand what graduate school is all about. The CIRC students are often amazed when graduate students explain how different graduate school is from undergraduate studies and how enjoyable graduate school can be, since most students find graduate school to be much more interesting (focused on an area of their special interest) and fun than undergraduate school.

Since all of the students in the program have financial need, most of them work. Working 20 hours or more a week and going to school full-time is very difficult and therefore most of these students are very eager to graduate as soon as possible so they can earn a good salary as an engineer. They expect their hard work to pay off: engineering is a very difficult major, but the initial salary is the highest of all baccalaureate degrees. In addition, many of these students have secured loans in order to get through school and want to get rid of their debt as soon as possible by working. It is hoped that with the CIRC Scholarship these students will not have to work or will be able to reduce their number of work hours. This has been true for several students. The students are quite surprised to learn that there are many sources of revenue for completion of graduate school. The students learn about assistantships (graduate, teaching, or research), graduate scholarships and fellowships, and that many companies will either pay for or reimburse

the tuition of their employees working on graduate degrees. A common myth is that in a somewhat tight market for new engineers, having an advanced degree will price them out of the market. The students are again surprised to learn, for example, that a large, local, engineering manufacturing company is currently giving 60% of their new hires to engineers with advanced degrees. This percentage, coupled with the fact that there are fewer engineers with advanced degrees competing for these jobs, makes graduate school quite attractive. Also, since the CIRC students are all U.S. citizens or permanent residents, they are all eligible for government-related industries that require citizenship.

By bringing in engineers from industry with advanced degrees, the students more readily use these speakers as role models. These industry speakers also talk about the opportunities in their own companies for an engineer with an advanced degree in engineering. In addition, many of the speakers are women or underrepresented minority engineers so the CIRC students can better identify with them. The students learn that the MBA is not for all engineers. These engineers also point out that their initial work assignments are usually quite different (more interesting and challenging) with a Masters degree rather than a Bachelors degree. A main point that catches the attention of the CIRC student is that the work they will do in industry will usually differ tremendously depending on whether they have an advanced degree or not. Often students who have had an industrial internship will have noticed that engineers with a Master's degree are usually in much more interesting jobs, have more autonomy, and earn more money.

III. The CIRC Program

As a condition of accepting the CIRC Academic Scholarship program, the scholars agree to attend at least four of five meetings during each semester. The meetings must be made up if there is more than one missed meeting. The meetings are an hour long and cover a variety of topics such as college success tips, resume and cover letter writing, networking and interviewing skills, graduate student panels, industry speakers with advanced degrees, how to approach a professor, finding internship and research opportunities, and many others. The scholars are also responsible for doing homework assignments related to the meeting topic. Homework assignments vary from investigating engineering research projects at ASU to summarizing what they learned from a guest speaker. Homework assignments are due at the following meeting. At the end of each semester, the scholars turn in a portfolio which contains their scholarship application, an updated resume, a copy of all of the semester assignments, and the semester meeting schedule. Their work is reviewed and returned to the scholar to keep. Based on feedback from the CIRC Scholars during the first year, the homework assignments are made lighter in the spring semester.

In an effort to make the meetings more enjoyable for the scholars, snacks and beverages are served at every meeting. Each meeting begins with a short icebreaker to give the scholars a chance to get to know each other on a personal basis. Scholars fill out an evaluation form after every meeting with suggestions for improvement and for new meeting topics that interest them. This feedback is used to tailor the meetings to the scholars' needs. The suggestions are summarized and handed out at the next meeting so that the scholars can see first-hand that their suggestions are being implemented and also see the comments of their peers.

Many students report that the meetings are helpful and motivate them to explore options that they had never considered before. One student commented, “I always felt motivated after our meetings...people could tell if I had just left a CIRC meeting.” Another student wrote, “I’ve learned so much – things that I need to know but classes don’t teach us. I’ve gotten to know my teachers better than ever before and I’ve pursued internships/research more this semester than all of my previous semesters combined.”

Having the scholars do homework assignments related to the meeting topic does more than just encourage the scholar to attend and to pay attention during the meetings. It also helps them think about and plan for their future. After reviewing hundreds of homework assignments, it becomes apparent that for many scholars, their consideration of graduate school fluctuates greatly in their writing. Requiring them to put their thoughts down on paper helps to generate deeper thought about the topic and facilitates their decision process. As one student put it, “I liked the topics and the people who were invited. It made me explore my options in depth and look at it in different ways.”

The homework can also add an element of accountability. When a scholar mentions in an assignment that they are going to follow-up with a professor or graduate student on a specific topic or they are going to attend a student organization meeting to get more involved, it provides an opportunity to inquire of the student about the experience. By asking the scholar if they have had the chance to meet the person or attend the event and how it went, it shows interest in their personal development and provides an opportunity to motivate them if they have not pursued the opportunity further.

Many homework assignments help to illustrate a scholar’s particular interest in a specific area of engineering. This can provide an opportunity to introduce the student to others who have similar interests. For example, there was a female scholar who was interested in the subject of orbital calculations. A different scholar, as part of an assignment, interviewed a student working on a research project where he calculated orbits in space. With permission from the interviewee, his contact information was passed along to the scholar who was interested in orbital calculations. She did not follow-up right away, but did say that she was planning to contact him soon to learn more about his research work. Another example involved several scholars expressing an interest in automotive engineering. The program coordinator of the scholarship program worked as a test engineer at General Motors in the past. Through personal industry contacts, several of the scholars were introduced to employees at General Motors and to industry contacts in the Society of Automotive Engineers (SAE). The scholars were also introduced to each other and encouraged to attend a student SAE meeting together. The students were given the opportunity to develop and to practice their networking skills and to broaden their list of professional contacts.

Another benefit, most unexpected, from the homework assignments was staff motivation. There was a scholar who wrote about her experience with her advisor and how the meeting was so beneficial to her. Her positive comments were forwarded to the advisor so that the advisor would know how her efforts had made a difference to this student. So many times, employees only receive negative feedback. It is nice (and very motivating) to receive unsolicited positive feedback once in awhile. The advisor was very grateful to receive the positive comments.

The CIRC students are motivated by learning that it pays to have an advanced degree. The average earnings of workers 18 years or older, by educational attainment from 1980-2002 show that in 2002 workers with a bachelor's degree earn 88% more than high school graduates: \$51,194 to \$27,280. Workers with graduate degrees earn 167 percent of that of the high school graduate: \$72,824 to \$27,280 and 42% more than those with just a bachelor's degree (Prism, December, 2004). If we note that the average salary for all workers is close to the starting salary of engineering baccalaureate holders, the value of a graduate degree in engineering is even more evident.

Probably the most evident positive result of the meetings and homework is the fact that it presents graduate school as an attainable and beneficial opportunity for the scholars. Most scholars report that they never even considered graduate school before joining the CIRC program. One student wrote, "I never really considered pursuing an education after the four undergrad years, but with the speakers that have been coming to speak with us, my attention has definitely been caught. I would still like to learn more about graduate school, but the benefits seem unending." Another student commented that "each meeting provides insight and light regarding post-graduate studies and has me thinking about them much more than I would be if I weren't attending these meetings." Another student, now planning to attend graduate school reported, "This is the best possible program that an undergraduate student could do. I have learned so much about graduate school, research, and the role of advanced degrees in industry." These comments and many more illustrate that the CIRC program effectively encourages scholars to seriously consider pursuing advanced degrees.

IV. Future Programming for CIRC Scholars

Programming for the CIRC Academic Scholars Program is difficult. The meetings are held 4:40-5:30pm on Thursday and repeated on Friday, because one time cannot be found that is available for all to attend. Sometimes an extra effort needs to be made to get two speakers for the two days and all of the students are not getting exactly the same message. Another difficulty is that the Scholars are juniors, seniors, and graduate students, and, in addition, some of the Scholars are in their first year with the program, some their second year, and some their third year. Therefore the specific interests of the students vary by where they are in their degree attainment and in their thinking about graduate school, as well as by what programs they have already heard. The same varying interests and need for information carries over to the homework. Each semester the students are requested to complete time management schedules for themselves. However, most homework allows options such as a choice between one of three alternatives: 1) talk to a professor whose research interests you to learn more about the research and to inquire if there are any open research positions, either paid or volunteer; 2) research three graduate schools that you are interested in attending and decide what you like and don't like about each one; 3) apply for a graduate fellowship. The students are to write up what they did and turn in the work as an assignment.

To assess the CIRC program for Fall 2004, a survey was given to the CIRC students at the end of the semester. The survey was completed by all of the CIRC students except three, two of whom

graduated in December 2004. Table 1 gives the demographics of these 17 students in order to understand the student mix a little better. Three of the 17 students had been transfer students, although transfer students usually are assigned to a different academic scholarship program (Anderson-Rowland, 2004b).

Table 1. Demographics of CIRC Students Who Completed a Survey Fall 2004

Gender	Renewal	Citizenship	Class	Transfer	Internship	UG Research	1st Gen.
F = 10	Yes = 14	U.S. = 15	Grad. =1	Yes = 3	Yes = 8	Yes = 9	Yes = 8
M= 7	No = 3	P. Res. = 2	Senior = 14	No = 14	No = 9	No = 8	No = 9
(Min. = 7)			Junior = 2				
Total = 17							

To evaluate the five Fall 2004 CIRC meetings, the CIRC students were asked to evaluate the meetings with a rank of 1 for very good/excellent, 2 for an okay/average, and 3 for a topic that was not helpful. Table 2 shows that most of the topics were very good/excellent for most of the students, especially the top four ranked topics: industry speaker, graduate panel, career services presentations, and meeting and getting acquainted with other students in the program.

Table 2. Fall 2004 Topics That Were Useful

Topic	Average Rank*
Industry Speaker	1.2
Graduate Panel	1.2
Career Services Offerings	1.3
Meeting, getting acquainted, discussing with other students in the program	1.3
Time management and Success Tips	1.5
Fulton Engineering Internship Program (EIP)	1.8

* 1 = very good/excellent, 2 = okay/average, 3 = not helpful

The students were then asked to rank topics that would likely be most useful to them for the spring semester. According to the ranks as listed in Table 3, financial planning, interviewing, the politics of industry, more graduate school information, and the politics of graduate school and research were selected as the most useful. Most of the lower ranked topics have already been covered in the program. The spring program will be planned using this information.

Table 3. Top Four Ranked Topics That Will Likely Be Useful Next Semester

Topic	Rank and # of times listed	Score*
Financial planning	1,1,1,1,2,3,3,4	24
Interviewing	1,1,2,2,2,3,3,3	24
Politics of industry	1,1,2,3,4,4,4	16
More grad school info	1,1,1,3,4	15
Politics of grad school/research	2,2,2,3	14
Industry speaker	2,2,3,3,4	11
How to work a career fair	2,3,3,4,4	9
A professor's life in a Research I university	1,3,4	7

Graduate student panel	2,4	4
Time management follow-up	2,4	4
Cover letters	1	4
MS vs MSE degree	1	4

* To compute score: Rank 1 = 4 pts., Rank 2 = 3 pts., Rank 3 = 2 pts., Rank 4 = 1 pt.

Not all students ranked their top four items.

V. Program Assessment

Of the 21 CIRC students in the first year (2002-2003) of the program, 10 (48%) of the students were female and 6 (29%) were underrepresented minority, with 14 (67%) either female or minority. Of the 18 new CIRC students in the second year (2003-2004), 11 (61%) were female, 7 (39%) were underrepresented minority, and 14 (78%) were either female or minority. The academic status of the 39 students as of December 2004 is shown in Table 4. Therefore, the program has done quite well in supporting women and underrepresented minority students.

Table 4. Academic status of CIRC students as of December 2004 including year of program, gender, and ethnicity					
Academic Year	Enrolled	BSE Completed	Enrolled BSE	MSE Completed	Enrolled Graduate
02-03 total	21	13	8	0	6
F	10	7	3		3
M	11	6	5		3
Min	6	2	4		1
03-04 total	18 (new)	11	7	1	4
F	10	4	5	1	1
M	8	7	2	0	3
Min	7	5	2	1	2
Total	39	24	15	1	10

Of the 24 CIRC students who have graduated with a Bachelor's degree, 10 are known to be enrolled in graduate programs, 8 of them at ASU. The CIRC Scholar who has completed her Master's degree came into the CIRC program as a graduate student. One of the graduates is beginning his post-baccalaureate work as a Marshall Fellow. The graduate students who did not continue immediately with graduate school have taken positions in industry with most of the students intending to pursue a Master's degree later with company support. One graduate fully intended to go directly to industry, but on the fourth round of interviews with the company he wanted to work for, he learned that the company would not support any graduate work and the locale of the job was not what he intended. He turned down the position and continued with graduate school. He will be receiving his Master's degree soon. Several of the 15 continuing students will graduate in May. All of the continuing students are in good standing academically and only three currently have a GPA below 3.0. Since the students enter the CIRC program at different stages in their academic career, it does not make sense to try to compare completion rates at this time.

None of the CIRC students dropped out of school. A few students have chosen not to remain in the program after one year, but these students have continued in good standing and are either still enrolled or have graduated. Since the CIRC students are required to attend four out of five workshops during each semester and to turn in a portfolio of completed homework at the end of each semester, some students determine that the effort that they must make for the scholarship money is not worth it, especially if they did not qualify for the full scholarship amount of \$3,125.

VI. Conclusions

The ASU CIRC Academic Scholarship Program is meeting its goals: graduating students and encouraging them to earn a graduate degree. In addition, the reviews of the students of the meetings show that the programs are meeting their expectations. Only a very few of the students leave the CIRC program still believing that they will never attend graduate school. Most students after graduating with their Bachelor's degree either continue on to graduate school or accept a job with an industry that will pay their tuition to go to school and expect to start a graduate degree when they have had a little break from school or have paid off some of their debt. The students are warned that it is very difficult to go to graduate school while working full-time in a new position. Some of the students are not sure of the direction of their graduate studies and so take a job to give them some more time to determine where their interests lie. Some do intend to get their MBA after a few years of industrial experience. Some students are inspired to think PhD and the possibility of an academic career. The following example is a typical story: When a CIRC student who will graduate in May 2005 was asked if she was going on to graduate school, she replied that she was next spring. She said that she definitely wanted to go to graduate school, but thought that she had started too late and would have to wait for spring 06 to get into the school that she wanted. She was encouraged to do as much work toward application as she could for next fall, since often schools commit all of their graduate support in the fall of the academic year. When asked if graduate school was part of her future plans when she first came into the program, she said, "Oh, no. I was not considering graduate school at all!"

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