How Did They Fare: Women and Underrepresented Minority Engineering and Computer Science Students in a Five-Year Program

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Abstract

The Collaborative Interdisciplinary Research Community (CIRC) program was initiated in Fall 2002, in the Ira A. Fulton School of Engineering, supported by a CSEM grant from the National Science Foundation. With a no-cost extension, the grant of $400,000 for four years actually supported the program for five years. The primary purposes of the program were to help academically sound junior and senior engineering and computer science students with financial need to improve retention and graduation rates, to expand their horizons about the field of engineering, to provide professional improvement, and to encourage the students to go on to graduate school full-time right after completing their degree. Students received CIRC scholarships of up to $3,125 per academic year, depending on unmet financial need. The program focused on women and underrepresented minority engineering and computer science students who made up close to 60% of the total enrollment in the program.

Sixty-seven CIRC students participated in the program with 45 of the 62 (5 entered the program as graduate students) undergraduates graduated with Bachelor's degrees and 22 of these students immediately enrolled in graduate school (40%, compared with 17.9% nationally). The program retention is over 95% in engineering and computer science. Forty-eight percent of the participants are female and 25.4% of the participants are minority students. A total of 39 CIRC students are either minority or female (58.2%). The average GPA of the Spring 07 students was 3.61.

This paper will review the enrollment and degree attainment of women and underrepresented minority students in engineering and computer science to give a case for special programs such as the one discussed. The results of the program in meeting its goal are presented. Also included in the paper are observations by program participants.

Introduction: Enrollment and Degrees

It is well known that women and members of underrepresented groups are severely underrepresented in engineering and computer science. The enrollment of undergraduate women in engineering had been slowly increasing since 1979. However the rate of increase has slowed since 1996 and the number of women engineering undergraduates in 2005 was lower than the number enrolled in 2001. There was a slight increase in women's enrollment during 2000-2003, but the enrollment has decreased since then. See Table 1. Further, the number and percentage of

women in engineering has decreased from 78,468 (19.1%) in 2001 to 70,579 (17.2%) in 2005. Similarly, decreases are seen in the Black undergraduate enrollment which decreased from 27,442 (6.7%) in 2001 to 24,343 (5.9%) in 2005. Native American engineering enrollment showed only a slight decrease from 2,458 (.6%) students in 2001 to 2,295 (.6%) in 2005. Only Hispanics showed an increase in engineering undergraduate enrollment and percentage: 31,482 (7.7%) in 2001 to 35,198 (8.6%) in 2005.

There do not seem to be indicators for an increase in interest in engineering and computer science. The intentions of freshmen to major in engineering or computer science are not encouraging. In 2004, 33.1% (Female 26.3%, Male 40.8%) of all freshmen had intentions to major in a science or engineering field. The percent of women interested in engineering and computer science was 2.9 and .4 percent respectively. The comparable numbers for males was 17.9% and 4.1%. Only 2.9% of female Black students were interested in engineering, while 1.5% were interested in computer science. Only 3.1% of Hispanics female students were interested in engineering and .6% interested in computer science. Of American Indian females, just 2.9% were interested in engineering and 0.5% intended to pursue computer science.

Year and status	All Undergraduates	Female	Male	White	Asian	Black	Hispanic	Native American	Foreign National
				Number					
All enrolled									
1995	363,315	67,286	296,029	249,896	38,329	25,569	25,998	2,103	21,420
1996	356,177	67,618	288,559	243,270	37,873	24,922	26,483	2,396	21,233
1997	365,358	70,765	294,593	246,950	39,475	24,809	30,580	2,422	21,122
1998	366,991	72,393	294,598	248,439	40,523	25,699	28,802	2,418	21,110
1999	361,395	71,376	290,019	243,560	39,891	25,419	29,111	2,396	21,018
2000	390,803	76,027	314,776	263,931	44,652	26,096	31,107	2,385	22,632
2001	409,557	78,468	331,089	275,248	47,937	27,442	31,482	2,458	24,990
2002	421,178	77,952	343,226	286,246	49,696	26,433	33,311	2,362	23,130
2003	421,791	75,934	345,857	284,498	49,602	25,986	35,230	2,425	24,050
2004	419,387	74,139	345,248	284,610	47,872	25,313	35,060	2,458	24,074
2005	409,326	70,579	338,747	282,421	43,385	24,343	35,198	2,295	21,684

NOTE: Race/ethnicity/citizenship categories are those used in the survey's data collection. SOURCE: Engineering Workforce Commission, *Engineering & Technology enrollments: Fall 2005* (Washington, DC, 2006).

TABLE 1. Undergraduate enrollment in engineering programs, by sex, race/ethnicity, and citizenship: 1995–2005

When we consider the Bachelor's degrees awarded in engineering to women and underrepresented minority students, the numbers lag the enrollment by a few years. See Table 2. The highest number of Bachelor's degrees awarded to women occurred in 2004 (15,282) with a slight decrease in 2005. The 14,868 engineering Bachelor's degrees awarded to women in 2005 represented 19.6% of the total engineering degrees awarded. The number of Bachelor's degrees awarded to African American engineering students has continued to steadily increase to 3,756,

but still only make up 4.9% of the total engineering degrees given. The picture is similar for Hispanic engineers who earned 4,890 Bachelor's degrees (a new high) in 2005 which represented 6.4% of the total degrees. In 2003, Native Americans hit a record for the number of engineering Bachelor's degrees: 388. In 2005, Native Americans earned a few less Bachelor's degrees: 378 (0.5%).

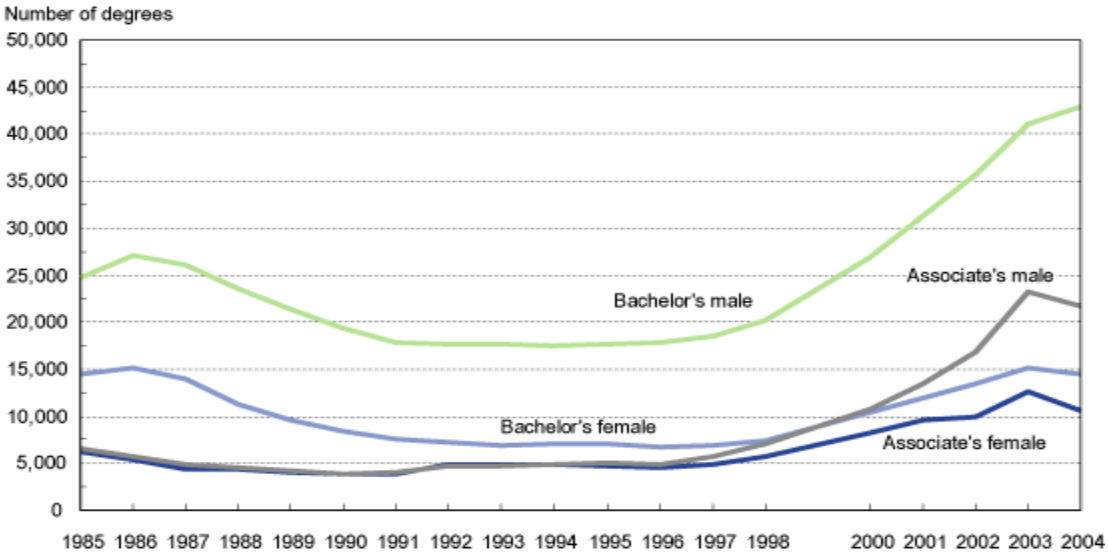
If we look for a moment at Computer Science, the gap in male and female degree earners in computer science has widened in recent years. Figure 1 and the following summary describe this gap (NSF, 2005):

				Race/ethnicity					
		Sex			Asian	African	Hispanic	Native	Foreign
Year	Total	Female	Male	White	American	American	American	American	National
1990	65,967	10,130	55,837	50,099	5,989	2,173	2,473	112	5,121
1991	63,986	10,016	53,970	48,028	6,305	2,304	2,663	146	4,540
1992	63,653	9,972	53,681	47,540	6,479	2,374	2,708	163	4,389
1993	65,001	10,453	54,548	47,976	6,764	2,637	2,845	175	4,604
1994	64,946	10,800	54,146	47,136	6,881	2,769	3,045	207	4,908
1995	64,749	11,303	53,446	46,264	7,056	2,897	3,409	230	4,893
1996	65,267	11,737	53,530	45,952	7,333	3,120	3,557	263	5,042
1997	65,091	12,160	52,931	44,976	7,625	3,203	4,005	265	5,017
1998	63,271	11,797	51,474	43,623	7,131	3,144	3,939	351	5,083
1999	62,500	12,360	50,140	42,650	7,226	3,171	4,073	328	5,052
2000	63,635	13,140	50,495	43,437	7,529	3,150	4,124	347	5,048
2001	65,195	13,195	52,000	44,407	8,340	3,182	4,152	275	4,839
2002	68,648	14,102	54,546	47,149	8,669	3,358	4,298	315	4,859
2003	75,031	15,114	59,917	51,297	9,705	3,429	4,652	388	5,560
2004	76,003	15,282	60,721	51,420	9,941	3,699	4,813	362	5,768
2005	76,003	14,868	61,135	51,302	10,033	3,756	4,890	378	5,644

NOTE: These data differ from data collected by the National Center for Education Statistics (NCES) due to differences in population covered and taxonomy. The primary difference is that these data include some degrees that are counted as computer science by NCES.

SOURCE: Engineering Workforce Commission, *Engineering and Technology Degrees, 2005* (Washington, DC, 2005).

TABLE 2. Bachelor's degrees awarded in engineering, by sex, race/ethnicity, and citizenship: 1990–2005



NOTE: National data not available for 1999.

SOURCE: National Science Foundation, Division of Science Resources Statistics, special tabulations of U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey, 1985–2004.

FIGURE 1. Bachelor's and associate's degrees awarded in computer sciences, by sex: 1985–2004

- Computer sciences Bachelor's and Associate's degrees earned by women dropped sharply in 2004, as did computer sciences Associate's degrees earned by men.
- The number of Associate's and Bachelor's degrees awarded in computer sciences increased substantially since 1997, especially for men.
- The female share of Bachelor's degrees in computer sciences dropped between 1985 and 2004 from 37 to 25 percent, as the number of such degrees awarded to women was about the same in 2004 as in 1985

What is the situation with Master's degrees in engineering? See Table 3.

				Race/ethnicity					
		Sex							
Year	Total	Female	Male	White	Asian American	African American	Hispanic American	Native American	Foreign National
1995	28,630	3,297	25,333	13,831	2,572	665	711	43	9,699
1996	27,761	3,360	24,401	13,576	2,621	674	748	56	8,996
1997	25,874	3,246	22,628	12,492	2,319	674	765	53	8,636
1998	26,138	3,440	22,698	12,085	2,451	714	807	54	9,161
2000	25,736	3,313	22,423	11,020	2,379	658	852	64	9,823
2001	26,523	3,373	23,150	10,466	2,414	700	838	60	11,001
2002	26,266	3,442	22,824	10,404	2,201	738	855	57	10,803
2003	29,704	3,536	26,168	10,726	2,444	827	876	70	13,374
2004	33,872	3,978	29,894	11,757	3,002	853	1,130	85	15,620

SOURCE: Women, Minorities, and Persons with Disabilities in Science and Engineering: 2007

TABLE 3. Master's degrees awarded in engineering by sex, race/ethnicity, and citizenship: 1995-2004

The number of Master's degrees earned in engineering has been increasing primarily due to the increased number of foreign nationals earning the degrees. The number of engineering Master's degrees to U.S. citizens/permanent residents was 18,931 in 1995 and 18,252 in 2004. The number of engineering Master's degrees earned by foreign national females has increased from 1,335 (40.5% of engineering Master's degrees earned by females) in 1995 to 3,157 (79.4% of engineering Master's degrees earned by females) in 2004! The number of U.S. citizen/permanent resident women earning Master's degrees has decreased severely in the past 10 years. These statistics clearly show the need for programs to help increase the number of women earning Master's degrees in engineering. From Table 3 we can also see that the number of African Americans earning an engineering Master's has been slowly increasing from 1995 to 2004 with an increase in percentage from 3.5% of U.S. citizen/permanent residents earning Master's degrees in 1995 to 4.7% of U.S. citizen/permanent residents earning Master's degrees in 2004. Hispanics have shown a definite increase in the number of Master's degrees with their percentage of domestic earned degrees increasing from 3.8% in 1995 to 6.2% in 2004. Native American numbers, although still very small, did show a nice increase among domestic engineering Master's by nearly doubling the number from 1995 to 2004 and increasing their percentage of the domestic engineering Master's degrees from 0.2% to 0.47%. However, even with these increases, it is clear that we need to encourage more underrepresented minority students to earn Master's degrees in engineering.

The number of women who earned doctoral degrees in engineering increased from 13.1% in 1998 to 18.3% in 2005. See Table 4. However, the number of women who are U.S. citizens/permanent residents who earned these degrees has decreased from 512 (68.3% of the female doctoral awards) in 1997 to only 478 (40.7% of the female doctoral degrees) in 2005. Therefore we see that the increase in the number of women earning doctoral degrees in engineering is all due to the increase in international women earning these degrees.

				Race/ethnicity					
		Sex							
Year	Total	Female	Male	White	Asian American	African American	Hispanic American	Native American	Foreign National
1998	5,921	773	5,110	2,170	557	81	110	13	2,874
1999	5,330	788	4,504	2,111	513	98	83	12	2,439
2000	5,323	838	4,459	1,890	440	81	82	8	2,750
2001	5,508	930	4,568	1,753	427	92	91	6	3,056
2002	5,077	891	4,172	1,478	408	85	98	6	2,912
2003	5,279	911	4,368	1,560	347	77	104	12	3,101
2004	5,775	1,021	4,754	1,547	354	94	88	6	3,588
2005	6,404	1,174	5,215	1,604	405	100	89	9	4,120

SOURCE: Woman, Minorities, and Persons with Disabilities in Science and Engineering: 2007

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Earned doctorates, 1998-2005.

NOTE: Totals include those with unknown gender and will not equal the sum of females and males in the respective columns.

TABLE 4. Doctoral degrees awarded in engineering by sex, race/ethnicity, and citizenship: 1997-2004

The number of U.S. citizens/permanent residents who earned engineering doctoral degrees fell from 3,047 in 1998 to 2,284 in 2005. Foreign nationals increased their percentage of engineering doctorates from 48.5% in 1998 to 64.3% in 2005. Of the underrepresented minority groups only African Americans showed an increase in the number and percentage of U.S. citizen/permanent resident doctoral degrees. Their number of engineering doctoral degrees increased from 81 (2.7%) in 1998 to 100 (4.4%) in 2005.

The Program and Results

We have seen that the women and underrepresented minority groups are not making significant strides in increasing their numbers in enrollment, Bachelor's degree, Master's degrees, and PhD degrees in engineering, except for a few cases (Hispanics in Master's degrees and African Americans in doctoral degrees). Therefore, encouraging more women and underrepresented minority (African American, Hispanic, and Native American) students to pursue undergraduate and graduate degrees is imperative.

A second issue is the retention of women and underrepresented minority students in engineering at the undergraduate and graduate level. The retention rate for undergraduates in engineering is less than 50% nationally. The retention rate for underrepresented minority engineering students is much lower. Many of these students do not drop out of school, but find other disciplines more interesting to them and some seek an easier major due to low academic performance. Some are not satisfied with their particular major, but do not consider other majors within engineering before switching to business, education, or other majors. Research has also shown that women in doctoral programs do not complete their degree at the same rate as men do.

All of the facts that we have looked at in this paper make a compelling argument for having an Academic Scholarship Program to increase the retention and graduation rate of undergraduate students, especially women and underrepresented minority students.

The low numbers of U.S. citizen/permanent resident students beg for something to be done about increasing the numbers. The extreme underrepresentation of women and underrepresented minority students demand that something be done to increase these numbers.

In answer to this dire situation, the National Science Foundation (NSF) created a Computer Science, Engineering, and Mathematics Scholarship (CSEMS) program. In the fall of 2002, a CSEMS program, funded by NSF (Award Number 0123146), was begun in the Ira A. Fulton School of Engineering at Arizona State University, with an emphasis on women and underrepresented minority students. The $400,000 grant for four years was stretched over five years and 67 students participated in the program. During the first year of the program a few transfer students were accepted. After the first year the transfer students were changed over to an S-STEM scholarship program funded by NSF focused on transfer students, as well as women and underrepresented minority students (Award Number 0324212).

The Fall 2002 program was called the Collaborative Interdisciplinary Research Community (CIRC). Qualified students had to be a U.S. citizen or permanent resident, full-time engineering or computer science student, have at least a 3.0 GPA, have at least a junior standing, and have financial need according to the FAFSA. The CIRC scholarship paid up to $3,125 per year, depending on unmet financial need. Applications were handled through the Engineering School's scholarship office. The application included some demographics, a statement of purpose, and two letters of recommendation, at least one from an instructor. The advertisement for the program and the application forms were on the School of Engineering's scholarship website. To encourage women and underrepresented students to apply, emails were sent and phone calls made by the program director. Sixty-two of the students were accepted into the program as undergraduates and five students were accepted into the program as graduate students in engineering. The results of these enrollment efforts and the degree achievements of the 67 students are shown in Table 5.

CIRC Enrollment and Academic Achievement 2002-2007										
	Total	Female	%	Min. Stu-dents	%	BSE/ BS earned	BSE/ BS still enroll	%	On To Grad School	%
Under graduates	62	25	40.3	16	25.8	55	5/1 in bus.	96.8/ 95.2	22/2 MBA	36.4/ 40
Graduates	5	5	100	1	20					
Totals	67	30	44.8	17	25.4					

TABLE 5. CIRC Enrollment and Academic Achievement by Gender and Ethnicity

As can be seen in Table 5, close to 45% of the participants are female and 25.4% are underrepresented minority students. A total of 39 CIRC students are either minority or female (58.2%). The average GPA of the Spring 07 students was 3.61. Over 40% of the undergraduate students in the program are female. This compares with less than 20% female in the School of Engineering. Nearly 26% of the CIRC undergraduate students are underrepresented minority students and for Fall 2003-2005, the enrollment of minority students in the School of Engineering was less than 20%.

Only two students of the 62 dropped out of school. One male who was a transfer students withdrew after two semesters of low academic performance. A female inexplicably withdrew from school with a 3.59 GPA. Neither of these students was a minority student. Therefore, 96.8% of the CIRC students have either earned a Bachelor's degree or are still enrolled at ASU. One student, a freshman minority student, who was accepted into the program as a special case the first year of the program, has switched his major to business. With this consideration, 95.2% of all CIRC students have earned a Bachelor's degree in engineering or computer science or are still enrolled in these majors. A second freshman minority student was also accepted that first year and this student has graduated with an engineering degree. Freshman and sophomore scholarship students have been supported through a NACME program from Fall 2003 on.

Of the five women who were admitted into the CIRC program as graduate students, three have completed their Master's degree and the other two are still working on their Ph.D. degree. It should be noted that nationally less than 18% of engineering student graduates go right on to graduate school full-time. Of the 22 students who went on to graduate school, 10 have completed Master's degrees (2 completed MBA's, one on a scholarship to Spain), 5 are enrolled in Master's degrees, and 9 are enrolled in PhD programs. Two students completed a Master's degree and are now working on their PhD. All except three of these students did their graduate work at ASU. It is possible that there are additional students in graduate school outside of ASU.

A check with ASU Institutional Analysis shows that approximately 10% of the engineering graduates at ASU continue on with graduate school in engineering at ASU. Of the 22 students that went on to graduate school, 9 (40.9%) were women and 5 (22.7%) were underrepresented minority students. The two MBA degrees were earned by females, one an underrepresented minority. Some additional students have enrolled in graduate school part-time while they work in industry. Other students say that they intend to attend graduate school in a couple of years when their company will support them for graduate school.

Several papers have been written detailing the CIRC Academic Scholarship Program and the workshop and assignments given to the students (Anderson-Rowland, 2004, 2005, 2006, 2007, 2008). The students met six times per semester for an hour. Refreshments were served to emphasize that the students are special. Each semester since the spring 2005 semester, the first meeting was on the Guaranteed 4.0 Plan developed by Donna O. Johnson (Johnson, 2004). The 4.0 Plan is a theory-based proven learning system for engineering students. Therefore, through this program, the students were given direct help on how to learn and how to earn A's. Students with a GPA of 3.5 and at least two semesters at ASU were not required to follow the 4.0 Plan. The other programs included: instruction from Career Services on resumes, interviewing, working career fairs, negotiation, career planning, and portfolios; information about research, information about graduate school, speakers from industry and academia, and information on

other resources in the School of Engineering or the University. The information on graduate school included what to look for in a graduate advisor and that the student should choose an advisor, not a school, with which to do graduate school. However, the most popular meetings were a panel of graduate students and engineers from industry with graduate degrees. The students interacted with the graduate students and learned how graduate school really is. Through these meetings many students came to realize that they, too, could do graduate school. Listening to the challenges and interesting work that engineers with graduate degrees are afforded in industry is often the clincher for a decision to go on to graduate school. Most students initially believed that graduate school was only for those going into academia. Most of the students going on to graduate school, even those going on for doctorates intend to go to industry. A few think that after a while in industry they might want to be a professor.

The following are some statements by the CIRC students when asked on a survey to identify which CIRC program components were helpful to them and if they answered "yes" to the program having increased the likelihood of attending graduate school, they were to explain:

- *4.0 Plan has been helpful in improving grades and securing graduation. Speakers and grad student panels encouraged me to apply to grad school.*
  New Graduate Student Fall 07
- *I already had good grades, but the organized part of the 4.0 Plan has helped me keep my grades up. I was not planning on attending grad school beforehand, but CIRC has helped me decide that I need to. I was also made award of Career Services available to me on campus.*
  New Graduate student Fall 07
- *I especially enjoy the industry engineers that visit. The Career Service presentations were very valuable. I have verified what a good choice graduate school is for me. CIRC contributed to my decision to stay at ASU for grad school.*
  New Graduate student Fall 07
- *All features of the program help me become a better student and future employee. If I didn't attend the CIRC program I wouldn't have considered graduate school. I will be working on how to make aerospace parts from scratch. I do intend on getting a Master's.*
  Graduated and Employee in industry Fall 07
- *The program has made me decide that I do want to attend Grad School!*
  Engineering Senior Fall 07
- *Speaking with faculty and people in industry. Some of the presenters informed me of the job opportunities that are available with an advanced degree.*
  Engineering Senior Fall 07
- *Good prep for grad school. I liked the speakers.*
  Completed Master's degree May 07
- *Director has guided me on applying for scholarships. The meetings have helped me on getting a better idea of what graduate students do after finishing.*
  Working F/T in industry and working on a Master's degree P/T Fall 07

- *I really enjoyed the career speakers (career services and industry speakers). It is a great program!*
  Graduated, third semester Master's student Fall 07

Conclusions

By all measures it would appear that the CIRC program has been successful. Nearly 60% of the students in the CIRC program are either a female or an underrepresented minority student or both. The females and minority students had a higher representation in the program than in the School of Engineering. Over 95% of the students have graduated with an engineering degree or are still enrolled in engineering. In addition nearly 97% have been retained at ASU. The program has been instrumental in increasing the number of students that continue on to graduate school, as well as in creasing the number of women and minority graduate students. Nearly 40% of the CIRC graduates have gone on to graduate school compared with less than 18% nationally. In addition, in the last 6 years less than 10% of the ASU engineering and computer science students have gone on to graduate school each year.

The CIRC program has been continued for another four years by funding from the S-STEM Program sponsored by NSF (Award Number 0631189). In this program students can receive up to $4,000 in a scholarship each year (which almost covers the current in-state tuition) depending on the student's unmet financial need. Based on student input, during the Fall 07 semester, a separate session was held with the graduate students in the program. The program director continually looks for additional programs and speakers that can be brought in to help the students.

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