

A Comparison of the Academic Achievements and Retention Rates of Women and Men Engineering and Computer Science Students in an Academic Scholarship Program Designed for Underrepresented Minority Students

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Abstract—This paper describes a study of the engineering and computer science students who have participated in a National Action Council for Minorities in Engineering (NACME) program for the past four years. The study compares the female and male students with respect to their ethnicity, their status as a first generation college student, their high school GPA and rank, and their retention in engineering and computer science. Retention comparisons are also made with minority engineering and computer science students who were not NACME scholars. Of particular interest are the differences, if any, found in the retention rates and GPAs of the female and male students. The paper suggests program changes for the differences found in this study that could help level the playing field and also offers recommendations for further research.

Introduction

In the last 20 years many academic scholarship programs have been established for underrepresented minority students in engineering and computer science, especially for those who are academically strong with financial need. Many of these students are first generation college students who may not have strong family support and understanding of the challenges of a college degree, especially an engineering or computer science degree. This paper examines the retention of minority students and results of one such program, the National Action Council for Minorities in Engineering (NACME) Academic Scholarship Program. The purpose of this paper is to analyze the retention rates of the NACME students, in order to compare the demographics of the female and male students and the NACME students' retention rates against minority students who were not a part of NACME. In addition the data will be analyzed for any possible causes for lack of program retention.

In the fall of 2003, Arizona State University (ASU) received one of thirteen block grants given across the nation by NACME. This five-year grant provided scholarship money for academically talented engineering and computer science minority students, who demonstrated financial need as determined by FAFSA. Incoming minority freshmen students are invited to apply. Each year many of the students who apply for NACME scholarships are students who participate in the Ira A. Fulton School of Engineering (Engineering) Summer Minority Engineering Bridge Program, a full-time, two-week, residential program provided at no cost to entering minority first-year student participants. Thus, many of the selected NACME students already know each other through this program.

The NACME Academic Scholarship Program was built on past research and program experience in Engineering at ASU. A Minority Engineering Summer Bridge Program was revitalized in 1994 for entering freshmen primarily to promote community and to ease the transition into the first Introduction to Engineering class. In 1996, an Academic Success for Minorities class (two semester hours) was created to go with the summer bridge program. Scholarship winners from the summer program were required to also attend the Academic Success class. The bridge program and academic success class relied heavily on the theory and successful practice of Raymond B. Landis (Landis, 1995). The success class coupled with the summer bridge program was instrumental in raising the one-year retention of freshman minority students in Engineering (Reyes, Anderson-Rowland, & McCartney, 1998). The Engineering programs for minority engineering students are also based on a research study which included a survey of eight universities in which showcased the best practices of their minority student programs (Morrison, C., Griffin, K., & Marcotullio, P., 1995). This study showed that specially designed programs for freshmen minority students were helpful at all of these universities.

The NACME students are selected based on their application that includes a personal statement of purpose, their GPA (usually at least 3.0), two letters of recommendation (at least one from a teacher), and their financial need. The major requirements of the NACME scholarship for entering freshmen are to enroll in the two-semester hour Academic Success course (FSE 194) and to complete the assignments given in that course for their first fall semester. In their second semester, the first-year NACME students meet every other week for an hour (eight times during the semester) and complete assignments. From their sophomore year on, the NACME students meet for an hour six times a semester. Special speakers make presentations on topics such as resume writing, interviewing, career planning, portfolios, graduate school, and why graduate school is good for engineers in industry. Assignments that help the student learn about research and graduate school are given each semester. If a NACME student maintains good grades, attends the meetings, does the assignments, and demonstrates financial need, then his/her NACME scholarship is renewed.

The purpose of the program is to graduate the student with a solid academic record and as a well-rounded engineer or computer scientist with knowledge in addition to what is taught in the classroom. The ultimate goal is to have the student continue his/her education in graduate school, preferably in a technical area. The general ASU NACME program has been detailed in previous papers (Anderson & Newell, 2004, 2005a). An evaluation after two years has been documented (Anderson & Newell, 2005b). In the beginning of the 2005-2006 academic year, a fundamental change was made in the NACME program with the introduction of the Guaranteed 4.0 Plan (Johnson & Chen, 2004). This learning system is built on learning theory and has been tested independently to show that it works. Ms. Johnson will give a student \$100 if she/he received the 4.0 training from Johnson, follow her plan exactly, and do not receive a 4.0 GPA for the semester. To date, no one has claimed a \$100. With this plan of time management for all 168 hours of the week, the GPA of the first semester NACME first-year students improved in a statistically significant manner. The 4.0 Plan and the results have been described in previous research (Anderson & Newell, 2006a, 2006b, 2007).

After the first year, students other than entering first-year students were admitted to the NACME program. In addition, after the first year, any student meeting the qualifications of the program

except for ethnicity (African American, American Indian, and Hispanic/Mexican American) is admitted to the program, but Engineering funds their scholarship. In addition, the NACME scholarship money has been leveraged in that some of the minority NACME students are supported by both NACME and Engineering funds. This paper, however, is focused only on the minority students who all received at least one NACME scholarship. Any student receiving a NACME scholarship for at least one semester is considered a NACME scholar even if he/she no longer receives a NACME scholarship due to low grades, incomplete attendance or assignments, inability to demonstrate financial need, or failure to reapply to the program at the end of an academic year.

Demographics

To date, 62 minority students have held NACME scholarships during the first four years. The breakdown of the total students by cohorts, classification, and gender is shown in Table 1. The first-year students all enrolled in the Academic Success Class for Minority Students (FSE 194) in their first semester at ASU, except for one student, a male sophomore, who took the course in Fall 2003, the beginning of his sophomore year.

Since one of the goals of the program is to encourage more women into engineering, we can see in Table 2 that the NACME program is doing well, with 33.9% of the minority NACME students being female. In Fall 2006, only 17.6% of the 3,885 undergraduate students in engineering and computer science were female. Of the 753 minority students in engineering and computer science, 25% were female. Table 2 shows the break down by gender for the NACME students who entered the program as first-year students, as transfer students, or as a sophomore or higher level student from the Fulton School.

Table 1. NACME Students by Cohorts, Classification, and Gender.

Cohort	Freshmen FSE 194		Transfers		Other*		Totals	
	F	M	F	M	F	M	F	M
Fall 03	7	14	0	0	0	0	7	14
Fall 04	3	8	0	0	0	1	3	9
Fall 05	3	7	3	4	0	1	6	12
Fall 06	3	6	2	0	0	0	6	6
Totals	16	35	5	4	0	2	22	41
Totals	51		9		2		62	

* Student entered program as neither a first-year nor a transfer student and did not take the Academic Success Course FSE 194.

Table 2. Minority NACME Students by Gender and Type of Entering Student, Fall 06.

Type	Female	Male	Total
First-Year	16	35	51
Transfer	5	4	9
Other	0	2	2
Total	21	41	62
%NACME	33.9%	66.1%	100%
%FULTON	25.0%	75%	

Table 3 shows the breakdown by ethnicity and gender of NACME students. Close to half of the NACME students are first generation college students. Table 4 shows the distribution of first generation college students by ethnicity and gender.

Table 3. NACME Students by Ethnicity and Gender, Fall 06.

Ethnicity	Female	Male	Total	%NACME	%Fulton *
African American	8	7	15	24.2%	15.1%
American Indian	4	4	8	12.9%	16.1%
Hispanic	9	30	39	62.9%	68.8%
Totals	21	41	62	100%	100%

*The Ira A. Fulton School of Engineering data is from the Office of Institutional Analysis (2006).

Table 4. NACME Students by Ethnicity and First Generation, Fall 06.

Ethnicity	1 st Generation Females?		1 st Generation Males?	
	Yes	No	Yes	No
African American	2	6	2	5
American Indian	2	2	2	2
Hispanic	4	5	17	13
Total	8	13	21	20
	38.1% Yes		51.2% Yes	
	46.8% Yes			

The NACME first-year male and female students are very similar in their high school GPA and their class rank, although the women on average graduated with a slightly higher GPA (3.65 to 3.50) and higher (lower) rank than the men and a larger percentage of the reported women's ranks were in the top 10% of their class as seen in Table 5. Since not all of the high school ranks were available, the number available is noted in the table.

TABLE 5. Comparison of High School Gradea, Class Rank, and Top 10% by Gender, Fall 06

Category	Female	Male
Average High School GPA	3.65 (n=16)	3.50 (n=35)
Average Class Rank	11.83% (n=12)	14.29% (n=31)
In Top 10% of Class	8/12=66.7% (n=12)	15/31=48.0% (n=31)

Retention In General

The first major goal of the NACME program is to retain students to graduation. Information about retention is summarized in Table VI. Since ASU is a large university and the NACME students are on the largest single campus in the nation, with over 51,000 students, there are many majors from which to choose and is very easy to switch majors. Of the 62 NACME students, five women and four men are currently not enrolled at ASU as of Fall '06 nor did they graduate. Clearly, as can be seen in the "Not Enrolled" category in Table 6, in terms of percentages (23.8% to 9.8%), the female students are not being retained at the university as well as the male students. However, a higher percentage of the female students have remained enrolled in engineering or

computer science. The difference is that a much higher percentage of the male students who left engineering and computer science are enrolled in other majors at ASU.

In most cases, the students who are no longer enrolled became discouraged or were dismissed due to low grades. Of the five women no longer enrolled, four first-year students had problems with their mathematics classes. One first-year female student earned a D in Calculus I her first semester and still managed to earn a 2.35 GPA. She repeated the Calculus I course with a B and

TABLE 6. ASU Retention by Gender, Enrollment, Major Change, and GPA, Fall 06

Category	Female	%	Ave. GPA	Male	%	Ave. GPA	Retention
Enrolled or Graduated in Engineering/CS	15	71.4		28	68.3		69.4% Engr/CS
Not Enrolled at ASU	5	23.8	2.61* 3/4>2.6	4	9.8	2.28 2/4>2.6	
Changed Majors and Enrolled at ASU	1	4.8	2.93**	9	23.0	2.51**	85.5% ASU***
(Changed Majors and Not Enrolled at ASU)	(1)	(4.8)	(2.98)	(1)	(2.68)		
Total Not Retained in Engineering/CS	6	28.6%		13	31.7%		
*Based on 4 students, 1 student did not complete any classes. **At time of major change *** 85.5% excluding student who transferred and is still enrolled.							

did not take another math class, although she continued on for another year and then left the University with a 1.94 GPA. Another first-year female student did not take a math class her first semester and did well academically. In her second semester she took a College Algebra class and earned a D. With a 2.55 GPA after her first year, she changed her major to undecided. She left the university after another year, for no apparent reason, with a 2.98 GPA. During her last semester she earned a 3.58 GPA! Another female student received a C her first semester for Calculus III. The next semester she withdrew from a Differential Equations course, completed the semester, but did not return the next fall, although she had a 2.84 GPA. Another female student earned an A her first semester in Calculus I. However, during her second semester, although she earned a B in Calculus II, she earned a D in Elementary Linear Algebra and an E (failure) in Physics I. In the summer she repeated the algebra class with a B and the physics with a D. In the second summer session she earned a D in Physics II. After the next year she did not enroll. She left the university with a 2.66 GPA. Another female student, a student with a 2.91 transfer GPA based on 64 hours of transfer credits, attended ASU for two semesters, but withdrew from all classes both semesters. Of these five students, only two were given the 4.0 Plan for time management during their first semester at ASU. These two include the female student who left with a 2.84 GPA and the female student who did not complete any ASU classes.

In the case of the male students, three of the four male students no longer enrolled at ASU were in the first cohort in Fall 03 and the fourth was in the Fall 04 cohort. One student failed his pre-calculus course his first semester, retook the course his second semester, and failed it again. He left with a 1.45 GPA at the end of his first year. A second male student earned a B in Calculus I,

but withdrew from Calculus II in his second semester. He transferred after his first year to be near his home. He pursued engineering for a while, but then realized that the math was more difficult for him than for others and that he did not enjoy math. He was more interested in health matters, so he changed his major to Integrated Physiology. He works out in a gym and would like to become a personal trainer. The third male student to withdraw from ASU earned a B in Pre-Calculus and a C in Calculus I the next semester. In his third semester he withdrew from the Elementary Linear Algebra class and failed Chemistry. The next semester he did not take any more math, but did take an elementary Chemistry class. His GPA was 2.24 and he did not return for his third year at ASU. A fourth male student to leave the University earned an A in Calculus I during his first semester. During his second semester, he withdrew from Calculus II. The next fall he took Calculus II again and failed the course. The following semester he retook Calculus II and again earned a failing grade. Since students are only allowed to retake a course once, the student did not return for his third year. He left the University with a 2.62 GPA. This last student did not take the Academic Success Class and none of these four male students had a 4.0 Plan to start their academic career.

Retention by First-Year Cohorts

By looking at the NACME students by First-Year Cohorts in Table 7, we can see the retention of each cohort as of Fall '06 and compare the retention rates to those for engineering and computer science minority students who were not NACME scholars and who did not take the Academic

TABLE 7. Retention of First-Year Cohorts by Gender and Compared to Engineering and CS Minority Students Who Were Not NACME Scholars

Fall 03	Fulton School NACME Minority Students	#	F	M	%	Fulton School Non-NACME Minority Students %
	(n=21)					(n=149)
	Enrolled/Graduated Engineering/CS	10	5	5	47.6	34.2
	Enrolled in Other College/Construction	6	0	6	28.6	26.2
	Not Enrolled	5	2	3	23.8	39.6
Fall 04	(n=11)					(n=121)
	Enrolled/Graduated Engineering/CS	8	2	6	63.6	41.3
	Enrolled in Other College/Construction	2	0	2	27.3	20.7
	Not Enrolled	1	1	0	9.1	38.0
Fall 05	(n=10)					(n=162)
	Enrolled/Graduated Engineering/CS	8	2	6	80.0	60.5
	Enrolled in Other College/Construction	1	0	1	10.0	17.0
	Not Enrolled	1	1	0	10.0	22.8

Success Class for Minority Students. We can look at the first three cohorts totaling 42 students in this way. We cannot include the Fall '06 cohort in this analysis since we do not know their one-year retention numbers.

In each of the cohorts, the NACME students have been retained at a better rate than minority students who have not held a NACME scholarship and the percentage of students who are not still enrolled at ASU is lower for the NACME scholars. At the same time, the number of NACME scholars enrolled at ASU in other Colleges or in Construction (a major contained within Engineering) is a bit higher for the NACME scholars than for other minority students.

Of the two “other” NACME students, both male students, who entered as neither first-year nor transfer students, one is still enrolled and one is not enrolled in engineering. Of the nine transfer students, as of Fall '06, one female student did not complete any credit hours in two semester tries and is not enrolled. Of the other eight transfer students, four females and four males, all are enrolled in engineering and computer science.

Although it is too soon to tell, it is expected that the retention of the students in engineering and computer science will increase with the Fall '05 and '06 cohorts over the Fall '03 and '04 cohorts who did not learn about the 4.0 Plan until Spring '05. These later cohorts had the advantage of learning earlier in their academic career how to follow a plan to earn all A's.

Discussion

We have considered the retention of the students in the NACME program, in general, and by first-year cohorts. We also considered each of these groups by gender. In general, the percentage of female students being retained in engineering and computer science is slightly higher than for the male students. However, a larger percentage of the female students have dropped out of ASU than the male students (23.8% to 9.8%). The other big difference between the genders is that many more of the male students (23% to 4.8%) have remained at ASU, but more have changed to majors outside of engineering and computer science. The findings indicate that all of the NACME students who are no longer enrolled at ASU seemed to have some difficulty with their mathematics courses. This discovery follows a pattern discovered in previous research (Anderson-Rowland, 1997). The grades earned in the first math class by first-year students who had remained in engineering and computer science and the first-year students who had left engineering and computer science were significantly different with a p-value of .0004. In fact, over 80% of the first-year students who had left had earned a C or lower in their first math class and over 80% of the first-year students who had stayed had earned at least a C in their first math class. Over 57% of the “stayers” had earned an A or a B in their first math class and about 57% of the “leavers” had earned a D, E (failure), or W (withdrew) in their first math class.

Most of the students who changed their major away from engineering or computer science, but who remained at ASU, had some difficulty with mathematics. Of the nine male students who changed majors, six received a C or worse in their first math course (3 C's, 2 D's, and 1 E). The other three received two B's and an A, but all three of these students received C's in their second math course. Some of these students also had difficulty with Physics and withdrew at least once from Physics or earned an E. The one female student, an Honors College student, who changed her major and is still enrolled, earned a 2.93 GPA her first semester including a C in her Calculus

I math class. She changed her major to psychology and then to nursing during her second semester.

Most of the students who remain in engineering and computer science received an A or a B on their first math class. Four of these students received a C or C+ in their first math class, but two of these students received an A or B on their next math class. One received a B on his third math class, but the other student received mostly C's in his math classes. Two students received a D on their first math class, but retook it for an A and a B+. One student actually received an E on their first math class, but retook it and earned an A.

It is difficult to predict who will change major. Some students change their majors often until they find the one they want. One student started as a civil engineering major. His first two math classes were Calculus I and II in which he earned a B and a C. He quickly changed to electrical engineering, but withdrew from his first electrical engineering course and failed the one-hour physics lab his second semester earning a 2.09 GPA. After staying out of school for a semester he returned as an undecided and then selected architecture as his major. He is now an Urban Planning major and is happy with his choice.

Although some students have changed their major to undecided because of low grades, others have chosen to go into a business major. In Table 8 we can see the major choices of the ten students still enrolled at ASU who have changed their major away from engineering and computer science and the two students who changed their major and are no longer enrolled at ASU.

TABLE 8. New Majors Chosen by Engineering and Computer Science NACME Students by Major, Gender, and Enrollment.

New Major	Number of Students			
	Still Enrolled ASU		Not Enrolled ASU	
	M	F	M	F
Conservation Biology	1			
Business or pre-Business	4			
Design Studies	1			
Urban Planning	1			
Construction	1			
Undecided	1			1
Nursing		1		
Integrated Physiology			1*	
Totals	9	1	1	1

*Transferred and still enrolled

The SAT and ACT scores, especially the math scores, were noted for all of the NACME students. Some students have just the SAT score, some have just the ACT score, some students have both, and some students have neither, making comparisons difficult. The SAT and ACT math scores averages were calculated to see if there was a pattern of the scores for the students who were still enrolled in engineering and computer science, who were still enrolled at ASU and had changed their major, and who were no longer enrolled at ASU. There were no obvious patterns. For the

'03 First-Year Cohort, the average SAT math score was higher (626.67 average) for the male student still enrolled in engineering and computer science than for those male students who had changed their major (555 average), but the ACT score was lower for the male "stayers" (22.33 average versus 24.66 average). In the '04 First-Year Cohort, the math SAT scored was lower for the male student "stayers" than for the male students who changed their major (541.67 average versus 555 average). In the '03 First-Year Cohort, the average math SAT scores was 586.66 (n=3) for female students versus 626.67 (n=3) for male students, but the math ACT average was higher for the female students (25 versus 22.33, n=3). However, the group sizes are just too small to make any valid comparisons.

CONCLUSIONS AND FUTURE STUDIES

The representation of female students in the NACME program is much higher than the percentage of female students in general in the Ira A. Fulton School of Engineering and also higher than the percentage of female students among the minority students in Engineering. The percentage of female students retained in the NACME program is slightly higher for female students than for male students; however a larger percentage of females leave ASU. Only one NACME female student to date has changed majors and stayed at ASU, while nine male students have done so. Almost all of the students who left ASU or left the NACME program had difficulty with their math classes. If an important goal of the NACME program is to have high retention, then the percentage of students retained would undoubtedly be raised if only students who would do well in mathematics were admitted to the NACME Program. In this case, at a minimum, a student would need to complete at least one math class at ASU and the math grade(s) would be examined before a student is awarded a NACME scholarship. If the student had all A's and B's in these math classes, the chances for retention in engineering and computer science would be higher than at present, but not guaranteed. On the other hand, students who had a D, E, or W associated with their first math class would be poor candidates for retention to graduation in engineering and computer science.

It is difficult to determine how to best use NACME Scholarship money. Should the scholarship money only be given to students with a high chance of retention or should more students be given a chance to prove themselves and have their chances for retention raised by being in the NACME program?

Since most of the students who have not been retained in the NACME program did not have the benefit of learning about the Guaranteed 4.0 Program in their first semester in the Fulton School, we do not know if the retention will be greater due to the higher first semester grades earned by the NACME first-year students with knowledge of the 4.0 Plan. We may find that even if students are doing well in their math classes, they may decide that another major besides engineering is more attractive to them. Since the reason that two of the female students left engineering with reasonably good grades (>2.6) is not known, the female students may be thinking that if they don't perform well in engineering, then they do not belong there.

The NACME female students do not seem to be less qualified in any way than the male students. They are being retained in the NACME program at a slightly higher rate than the male students. Therefore, it does not seem that any particular programs for the female students are needed. In order to raise the retention rate of NACME female students at ASU, perhaps the option of

changing to another major in ASU should be discussed with the female students so that they will consider this an alternative to dropping out of college.

Future studies will look to see if the retention of both female and male students is improved because of the presentation of the Guaranteed 4.0 Plan during the first semester at ASU. Before NACME students begin their first year, the NACME director should emphasize to the students that they should not enroll in any math class for which they are not prepared and when in doubt, it is better to review the math by stepping back and retaking a math class. However, if the student considers the class a review and does not put good work into the class, the class will not serve its purpose of enabling the student to be well prepared for the next math class.

As of May 2008, three of the NACME scholars have graduated in engineering. A female student, who graduated earlier, obtained her “dream job” in industry right after graduation. Two female students graduated in May 2008: one student will go on to graduate school full-time next fall and the other student has not yet decided what she will do next fall, although graduate school is still an option.

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