An Analysis of a Scholarship Program for Underrepresented Ethnic and Women Engineering Students and its Impact on Retention and Academic Performance

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ABSTRACT

Research indicates the importance of scholarships and academic support for underrepresented engineering student populations as a strategy for increasing their enrollment and graduation numbers. This paper examines the results of a 2006 NSF S-STEM award consisting of (36) scholarships for underrepresented ethnic and women students entering the University of Cincinnati College of Engineering beginning the fall of 2007, and the impact on the new grant proposal to fund students for 2010 – 2011.

Literature Review

There has been an increased level of discourse on the national and state level regarding the number of students entering and completing (STEM) disciplines in general and underrepresented student populations in particular. A number of reports highlight this challenge, reports, notably, those of the Building Engineering and Science Talent (BEST) *The Quiet Crisis: Falling Short in Producing American Science and Technical Talent* (2004), National Science Foundation (NSF) *Shaping the Future* (1996), the National Academy of Sciences *Rising Above the Gathering Storm* (2007), National Action Council for Minorities in Engineering, Inc. (NACME), *Confronting the "New" American Dilemma* (2008), and the *Ohio Board of Regent's* Science and Mathematics Education Policy Advisory Council *Science and Mathematics A Formula for the 21st Century Success* (2008).

The initiation and development of state and national reports lie in the over - all concern that in a world where economic competiveness is measured by a country's science and technological capacity; the United States is not currently positioned to meet the challenge of producing the engineers and scientists needed to compete on a global level (Council on Competitiveness 2001). The challenge is to increase the number of underrepresented ethnic students and women who enroll and graduate in STEM in general and engineering in particular.

The problem is acute for underrepresented ethnic students; for example, approximately 690,000 underrepresented ethnic students graduated from high school in 2002. Only 28,300 (4%) were considered "engineering eligible" based on courses taken and grades. Of these, 16,800 (59%) enrolled as freshman in engineering schools, out of 107,000 total admissions (CPST 2003). In that same year, there were 60,369 baccalaureate degrees awarded, of those Latinos earned 4,136, African American 2,982, and American Indian 308. Moreover, the number of *foreign national undergraduate* students awarded baccalaureate-engineering degrees in 2008 was 6.7% compared to 4.9% for African Americans and 6.2% for Latino students (Gibbons 2009). Given the fact that these underrepresented students of color will represent the majority of high school graduates in 2010, we must develop strategies to increase the number of them who are qualified for admissions.

While there is major concern with the enrollment of these students to engineering, a similar challenge exist in the number of these students who can afford the ever - rising educational costs (NACME 2008).

Overview

In the fall of 2007, (36) students were awarded Science Technology Engineering Math (STEM) Scholarships funded by a National Science Foundation grant and the University of Cincinnati (UC). The granted funded (32) students with the university providing funding for an additional four for a total of (36) students. Each student was offered a scholarship of $9,399 per year the cost of in state tuition for five years. For these funds, $3,390 per year is provided from the NSF award and the remaining $6,009 per year is provided from other College of Engineering scholarship funds.

High School Demographics of Selected S-STEM Scholars

Demographics S-STEM Scholars Selected

- Gender distribution: Females = 24 (68.6%) and Males = 11 (31.4%). Total = 35 students who participated in the program, during 2008-2009.
- Ethnic distribution: Ethnic minorities = 19 (54.3%), Asian American = 2 (5.7%), and White Caucasian = 14 (40%)
- Degree program distribution:
  - Aerospace Engineering 4 (11.4%)
  - Biomedical Engineering = 8 (22.8%)
  - Civil Engineering = 3 (8.6%)
  - Chemical Engineering = 10 (28.6%)
  - Computer Engineering = 1 (2.9%)
  - Computer Science = 2 (5.7%)
  - Electrical Engineering = 0 (0%)
  - Materials Engineering = 1 (2.9%)
  - Mechanical Engineering = 6 (17.1%)
- Degree distribution:
  - Regular BS degree program = 31 (88.6%)
  - ACCEND dual BS/MS degree program = 4 (11.4%)
- Residence status:
  - Ohio residents = 26 (74.3%)

The objectives were:

1) In five years, the recruitment of women engineering students will be increased from 16% to 21% of the freshmen students relative to the Fall 2005 enrollment.

2) In five years, the recruitment of underrepresented ethnic engineering students will be increased from 5% to 10% of the freshmen students relative to the Fall 2005 enrollment.

3) In five years, graduate 74% of the students from these targeted populations relative to Spring 2006.

The goals 2007-2008 were:

(1) A seven-week residential Summer Bridge Program was offered for incoming underrepresented ethnic engineering freshmen.
(2) Supplemental Freshman Cooperative Learning Classes in Pre-Calculus 250, Calculus 251, 252, 253, Physics 201, 202, and Chemistry 101 for all Bridge students
(3) Freshmen Learning Community Experience for majority and minority women who did not enroll in Supplemental Freshman Cooperative Learning Classes.
(4) An Academic Assessment and Monitoring program for retention of all S-STEM Scholars coordinated by the PIs.
(5) Six monthly socials to bring all the S-STEM Scholars together to meet and interact with university faculty, personnel and industry representatives.
(6) A voluntary service learning experience.

The goals 2008-2009 were:

(1) Supplemental Sophomore Cooperative Learning Classes
(2) Continuation of the Academic Assessment and Monitoring program
(3) A department-based Academic Advising Program
(4) Continuation of the Monthly Socials
(5) Development and implementation of a structured Voluntary Service Learning Experience
(6) Planning and recruitment for the 2009 Summer REU Program

Overview of Retention Strategies

Academic Advising and Performance Monitoring

Each of the grant PI(s) was assigned about 10-11 students each monitor S-STEM student's matriculation in the college. Students met with them once every quarter to discuss the previous academic quarter. Each student was required to turn in a minimum of three progress reports from faculty for courses and turn in their form indicating that they met with their departmental advisor. The progress report allows students to develop a relationship with faculty, and to use the progress reports as assessment tool and make the necessary adjustments in their courses. The grant PI(s) complete a "Student Consultation Form" during each quarterly meeting, which contained responses to the following: (1) Has student met with her/his instructor(s)? (2) Has student met with her/his advisor? (3) Issues/Topics Discussed, and (4) Recommendation(s). The PIs and the student agreed on recommendations to continue or enhance academic or professional development and the students sign the form.

In addition to the quarterly meetings, students are required to have all their instructors complete an academic progress report for each of their classes. Students are required to turn in three reports per class. The objectives are to increase the interaction between the students and faculty; and to provide a structured process for students to monitor their academic performance and make the necessary adjustments.

Supplementary Instruction

The S-STEM Scholars were encouraged to participate in a series of one - hour credit math and science cooperative learning courses that meet twice a week. The impact of cooperative learning has been documented (Slavin 1983), (Johnson, D.W., Johnson, R.T., and Holubec, E.J. 1990), and (Moore 2005, Vol.36, No.5, pp. 529-537). These courses are supplemental instructional courses in Pre-Calculus, Calculus, and Physics first taken in the freshman year; and Calculus IV, and Differential Equations for the sophomore year. The course grade is based on attendance and implementing the cooperative learning process. The goal is for 100% of students to earn a C or better in their corresponding course lecture. The following *five essential components* must be present for effective Cooperative Learning: (1) Develop positive interdependence so students cannot succeed unless their group mates do (and vice versa). (2) Facilitate face-to-face interaction so students are aware of each other's learning processes. (3) Promote accountability by evaluating individual performance and sharing the results with the group. (4) Encourage development of interpersonal and small group skills by discussing and promoting the social skills required for high quality collaboration. (5) Organize reflection on group performance so students focus on improving effectiveness of group work.

Monthly Socials

Monthly socials were held for the S-STEM Scholars and refreshments were provided. This activity is used to bring the scholars together to meet university faculty and industry representatives who discuss academic strategies, co-op opportunities, research experience opportunities, graduate school and career trends. The monthly socials were held from October through April and consisted of the following themes; "Service Learning Initiative", "Co-op Opportunities", "Why Graduate School", "Research Experience for Undergraduates", "Sustainable Urban Engineering Minor", "Challenges and Opportunities of Global Competition.

Mentoring

Research indicates the importance of mentoring for underrepresented ethnic students and women from undergraduate through their post-baccalaureate career (MentorNet 2008). Freshman underrepresented ethnic S-STEM students were selected to participate in the General Electric Aviation/Emerging Ethnic Engineers Mentoring Program (21st year). *The graduation rates for this program from 1988-2009 are 69% (engineering), 74% (engineering technology), and 85% (university). Also, of the 24 current GE Mentors, 5 are former E3 students.*

As part of the scholarship proposal, the university allocated funds for participation in MentorNet. All S-STEM students are encouraged to participate in this mentoring program. This program provides one-on-one mentoring to women and other underrepresented engineering and science students with professionals in their field.

Service Learning

A new component implemented in 2008 – 2009 was a requirement that all S-STEM Scholars participate in a service - learning project. We believe that their participation will enhance their educational experience (Astin, A., and Sax, L., 1998, Vol. 39, No.3, pp. 251-263). Part of the strategy is to get the scholars to do projects in schools where there are significant numbers of underrepresented elementary and or high schools students and to increase awareness of STEM. Each S-STEM student was required to perform 10 hours per quarter of voluntary service during the quarters they are enrolled in classes.

Evaluation

The University of Cincinnati Evaluation Services Center conducts the evaluation of the evaluation of the NSF S-STEM grant. The purpose is to assess the in progress goals that support meeting the five-year objectives of the scholarship program. The principal investigators met with the evaluation team to develop a plan to measure specific objectives related to academic performance, retention, and graduate school participation. The evaluation team determined that they would use the following four questions to evaluation the effectiveness of the scholarship grant program. Data for academic performance is collected each quarter and compared with college of engineering students; an annual survey is conducted with the students to gage the effectiveness of the scholarship program. Students will also complete an evaluation after each programmatic activity.

Results

At the beginning of the 2007-2008 academic year, there were 36 students in the S-STEM program. Eight of those students left the program and four students were added to the program, bringing the total number of students to 32 for 2008-2009. Table 1 on illustrates the retention rate of the Cohort 1 S-STEM scholars for the 2007-2008. Table 2 represents Cohort 1 and Cohort 2 consisting of the students who started the program in the 2008-2009. The freshman to sophomore retention rate for S-STEM Scholars was (83%) compared to (75%) for all engineering students.

1) To what extent and in what ways has participation in the S-STEM program activities impacted student attrition level?

Table 1: Student Retention 2007-2008

S-STEM Students	Stayed in CoE S-STEM Program	Stayed in STEM Fields	Stayed at UC	Left UC
36 students – Cohort 1	30	30	35	1
Retention rate	83.33%	83.33%	97.22%	3.6%

Table 2 shows the rate of retention for the first two quarters of 2008-2009. Two students left the S-STEM program these students were replaced by four additional students to maintain 32 students in the program. Program staff that provides information on grades and participation in program activities of each S-STEM scholar maintains a database. The extent to which program activities have aided in the retention of the students will be assessed in program review and in student surveys at the end of the year.

Table 2: Student Retention 2008-2009 (up to Winter Quarter)

S-STEM Students	Stayed in CoE S-STEM Program	Stayed in STEM	Stayed at UC	Left UC
30 students – Cohort 1	28	30	30	0
Retention rate	93%	100%	100%	0
4 Added (08/09) – Cohort 2	4	4	4	
Retention rate	100%	100%	100%	

2) To what extent and in what ways has the student's interest in attending graduate school changed as a result of participation in the S-STEM program?

To address this evaluation question, a student survey will be created to measure current and ongoing student interest in graduate school. Similar questions in subsequent years will be asked to assess the change in interest level. Current engineering graduate students and university personnel are invited to one of the monthly socials to discuss the importance of graduate school, and what students should do to develop their portfolio for admissions.

3) To what extent and in what ways has participation in the S-STEM program activities impacted student's interest in attending graduate school?

The GPA average and cumulative GPA and standard deviation for each quarter of 2008-2009 attained by the S-STEM Scholars is shown in Table 3. At the end of winter quarter, the average cumulative GPA of the S-STEM scholars was 3.20 (n=30), compared to 2.91 (n=328) for College of Engineering sophomore students.

Table 3. Average and Cumulative Grade Points

Item	At End of Academic Year 2007-2008	At End of 2008 Fall Quarter	At End of 2009 Winter Quarter	At End of 2009 Winter Quarter Including the New Participants
Mean GPA	3.315	3.244	3.282	3.263
Standard Deviation	0.333	0.366	0.318	0.364

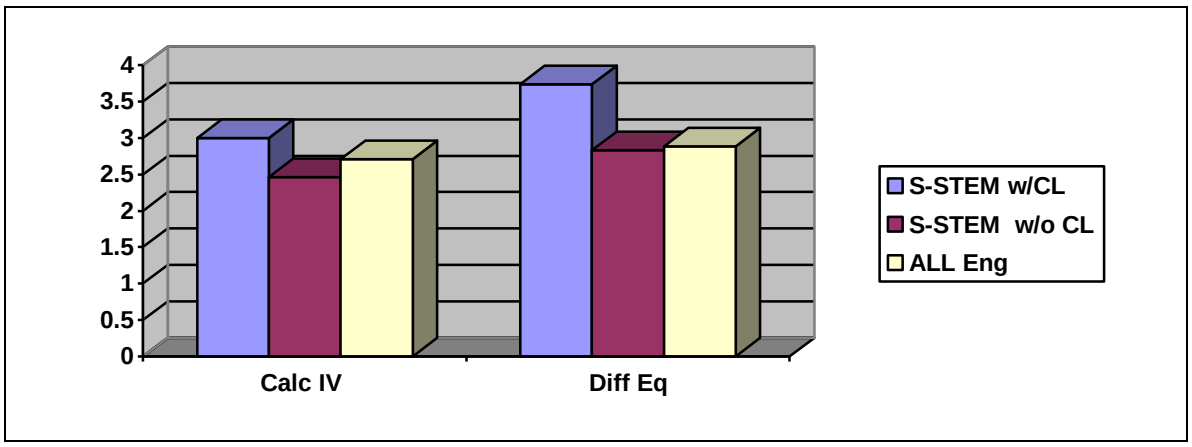
4) To what extent and in what ways has participation in the S-STEM program activities impacted student academic performance?

The S-STEM students are required to maintain a grade point average of 2.75 to remain in the program. At the end of winter quarter, the average cumulative GPA of the S-STEM scholars was 3.20 (n=30), compared to 2.91 (n=328) for all sophomore CoE students (2008-2009).

Cooperative Learning Courses for Calculus IV and Differential Equations were available to S-STEM scholars in the fall quarter of 2008 and the winter quarter of 2009 respectfully. These supplemental courses provide additional instruction and problem-solving support for those students enrolled in Calculus IV (15-MATH-264) and Differential Equations (15-MATH-273). The S-STEM students who participated in the cooperative learning courses earned a higher grade in these classes than S-STEM students and other engineering students who did not take the course. There were six students, of 19 who were eligible, who participated in the Calculus cooperative learning course. The average grade in the Calculus IV Math Course for these six students was 3.0, compared to 2.46 for the 13 S-STEM students who did not take the cooperative learning course.

The average grade for all of the engineering students (n=354) who took Calculus IV during the fall of 2008 was 2.71 as shown in Figure 1. Nine S-STEM students participated in the differential equation cooperative learning course out of the 14 who were eligible. The average grade for those nine students was 3.74, compared to 2.83 for the five S-STEM students who did not take the cooperative learning course. The average grade for all engineering students (n= 236) who took differential equations during winter quarter of 2009 was 2.88. The number of students who attended these cooperative learning classes was small compared to the total number of students, so caution should be used in drawing inferences from these results.

Figure 1. S-STEM Students Grades for Differential Equations and Calculus IV



Conclusions

The S-STEM program retained 83% of the students from the freshman to sophomore year, compared to a 75% retention rate for the College of Engineering.

The S-STEM student's academic performance is higher than the required 2.75 GPA average. At the end of winter quarter, the average cumulative GPA of the S-STEM scholars was 3.20 (n=30), compared to 2.91 (n=328) for all sophomore engineering students (2008-2009). While the participation in the cooperative learning courses for mathematics was small, the students who attended appeared to benefit from the course.

The cooperative learning courses seem to have an effect on the grades of the students who enrolled in these courses. A better indication of the effectiveness of the cooperative learning courses may be attained by comparing future S-STEM who take these courses and their corresponding lecture grades in the math and sciences, compared to engineering students who do not take the supplementary instruction courses.

Recommendations

With regard to future S-STEM grant proposals we will concentrate on increasing the number of underrepresented ethnic students based on the following data. The enrollment for majority women from the 2004 – 2005 through the 2008 – 2009 academic year is 15.38%, while the percentage of underrepresented ethnic students for the same time period is 5.42%. Also, a recent study in the college indicated that underrepresented students have 40% more financial need than majority student in general and women in particular.

The impact on enrollment as related underrepresented ethnic students without the S-STEM scholarship was more severe. Underrepresented enrollment increased 53% from fall 2006 to 2007 the year we awarded our current S-STEM Scholarships, and decreased 40% from fall 2007 to 2008 in the year after the NSF S-STEM scholarship awards were not available. The enrollment of women engineering students did not decrease. Specific programmatic recommendations are:

1. We have determined that all S-STEM students participate in the retention activities in order to increase the probability of academic success and persistence.

2. Require a signed contract outlining scholarship renewal criteria, academic, and program expectations.

3. Offer a structured service learning opportunities through our community engagement K-12 after school program to meet the volunteer service requirement. This provides students an opportunity to do their service learning around STEM activities and assist with pre-college initiatives.

4. Implement a departmental peer - mentoring program supported by a faculty advocate group.

5. Require students to document their participation in the scholarship program through a process of reflective writing, specifically an e-Portfolio.

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