

# A Scholarship Model for Student Recruitment and Retention in STEM Disciplines

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## Introduction

Many programs exist with a primary objective of increasing the number of science and engineering graduates among underrepresented groups in engineering (African American, Hispanics, Native American) including women, low-income families, and people with disabilities. These programs are influenced by demographic trends that project women and minorities to make up a substantial part of the population workforce in the United States [1]. In the wake of new millennium, ethnic minorities and women still remain underrepresented in a number of occupations, including those, which might be identified as high-technology areas [2]. Though women comprise half the high school graduates, only a small part of them choose engineering as their career. Men earned the majority of bachelor's degrees awarded in engineering (80%), computer sciences (78%), and physics (79%) [3]. The reasons for this low number of degrees awarded to women include that through policies and practices, educational institutions often ignore the issues unique to women, and fail to address aspects critical to their future. For example, they fail to encourage them in course work and in practices that are necessary in order to enter professional disciplines [4].

The number of bachelor engineering degrees awarded in the United States has increased in the past decade by 8%, but has reduced compared to the number awarded in 1986 by 12.8% [5]. This increase in the number of engineering graduates was restricted only to certain fields while the others still faced a decline. The engineering disciplines that accounted for this increase include aerospace, biomedical, computer, electrical, and petroleum engineering. However, enrollment in several other engineering fields such as chemical, civil, industrial engineering continued to decline [6]. In spite of the increase in the enrollment in science and engineering, the graduate student enrollment of US citizens and permanent residents continued to drop [6].

Addressing this common problem, this

paper describes how the Computer Science, Engineering, and Mathematics Scholarship (CSEMS) program at Wright State University (WSU) has proven to be a recruitment and retention model in the Science, Technology, Engineering and Mathematics (STEM) disciplines. The primary objectives of the program are: (a) increase recruitment of underrepresented minorities in STEM disciplines; (b) focus on academic excellence and preparation of minority and female students entering STEM disciplines; (c) emphasize the competency of students; and (d) enhance diversity in STEM disciplines, where women and minorities are underrepresented. The primary goal of this program is to emphasize success by removing artificial barriers, rewarding performance, and providing non-threatening environments for females and minorities. This goal is achieved through scholarship programs, career orientation workshops, participation in co-op and internship programs, and academic and social support.

## Background

Previous literature [7-10] has provided excellent summaries of programs in minority career developments. Based on the career development models, Lam, et al [11] developed a general framework to understand success in engineering among African American students. They theorized that success would be a function of several variables including: a) math and science knowledge (e.g. math courses completed, math achievement, math self-efficacy, science courses completed, science achievement); b) career orientation (e.g., commitment to engineering as a career, reasons for pursuing engineering as a career, opportunity to pursue an engineering career); c) educational and occupational values and beliefs (e.g., value to cooperative versus individualistic approaches to learning, value of community versus individualism); d) social support (e.g., role models, family support, peer support, faculty support); and e) self concept (e.g., general self-efficacy, instrumentality, competence).

## Abstract

A scholarship program offers enrichment, support, improved professional development towards employment, and increased graduate opportunities for underrepresented groups. In this paper, it is postulated that the development of a successful and competitive scholarship program is dependent on several variables including management leadership in quality sciences, cognitive/non-cognitive selection methods, operations research, active learning, and technical instruction supported by existing university student-support infrastructure. The effectiveness of the program is measured from the student grade point average, student distribution based on their STEM major, and retention towards graduation. This program can be effectively used as a model to develop activities for minorities and women, and for career interventions in areas where these groups have been traditionally low in numbers.

Aspray and Bernat [12] suggested that career opportunities for the underrepresented students can be increased by actively encouraging them to attend conferences and exhibits hosted by the National Society of Black Engineers (NSBE), Society of Women Engineers (SWE), and Society of Hispanic Professional Engineers (SHPE). By focusing on underrepresented minorities, these societies reinforce a message to underrepresented students, the various advantages of pursuing research and actively participating in such meetings.

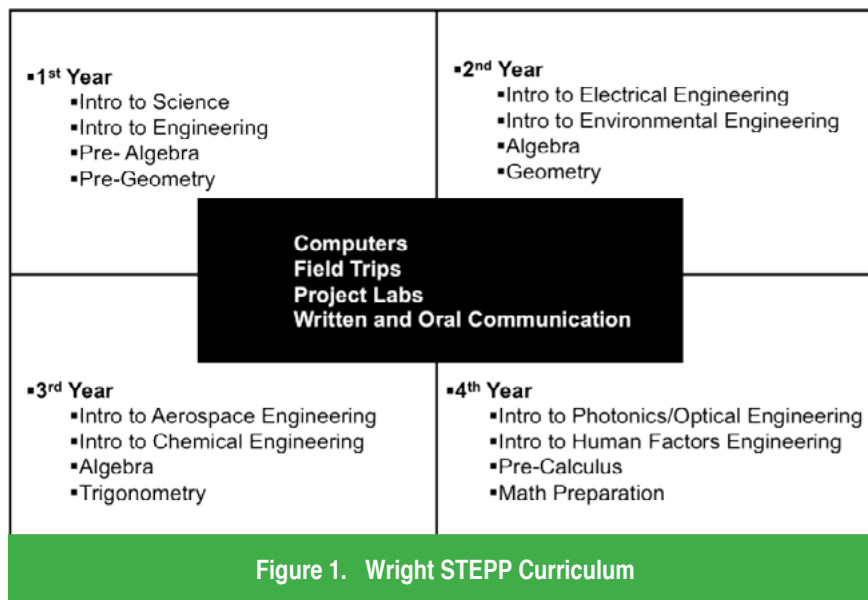
According to Landis [16], underrepresented students suffered from ethnic isolation, lack of peer support, lack of role models, and low faculty expectations. Landis believed that European American students often had the benefit of fraternities and other social groups, which offered to them the appropriate, supportive learning environment. Women and underrepresented students were seen as in need of the same type of opportunity to participate in a collaborative learning environment, one that includes peer support and upper class mentors. This could be achieved through a program that includes group study, clustering into classes, a student study center, and active faculty involvement.

## Program Description

### 3.1 Wright STEPP

The National Science Foundation-Computer Science, Engineering, and Mathematics Scholarship (NSF-CSEMS) Program at the College of Engineering and Computer Science at Wright State University (WSU) was initiated in 1999 with the collaboration of Wright STEPP (Science Technology and Engineering Preparatory Program), Dayton Public Schools (DPS), and Local Community Colleges. Wright STEPP is an academic fortification pre-engineering program initiated in 1988 to raise the aspirations of young students in the Dayton vicinity. The objective of Wright STEPP is to provide academic preparation and financial incentives for students to pursue degrees in STEM disciplines and provide an opportunity to attend college.

The participants in Wright STEPP program are under-represented students in the 7th through 10th grade from DPS. Every year, forty students from the 7th grade are admitted into the program, with a minor replacement in higher grades. Overall, 160 students (40 from each grade 7th - 10th) attend this four-week program that operates on WSU campus. For four weeks during the summer, these students take a full



schedule of academic classes, which include mathematics, physics, biology, chemistry, information technology, and other engineering disciplines. Figure 1 shows the typical curriculum of Wright STEPP with respective focus areas. Through contact with successful engineers and scientists from WSU, WPAFB, and local industries, Wright STEPP students receive a first-hand opportunity and head start in higher education through a hands-on technology-based environment. Students learn not only math and science, but also written and oral communication skills, problem solving and study skills, and gain career opportunity awareness. From 2001 to 2009, of the 40 students that graduate from Wright STEPP each year, the number of students enrolling in WSU has increased from 20 to 30 each year. This increased number demonstrates that student motivation to pursue higher education increased through participating in Wright STEPP program.

### 3.2 Student Recruitment

One of the common misconceptions of low student retention in engineering is students' lack of academic ability. Besterfield-Sacre et.al [13] have shown that there is little to no difference between student's who leave engineering and those who remain in engineering. They [13] have also shown that models incorporating cognitive variables such as student high school math and science ability, and basic engineering knowledge are able to better predict student retention. In addition, Zhang et al. [14] found that high school GPA and SAT math scores were the best predictor of retention and graduation.

Astin et al. [15] found that student high school record was the best predictor of academic success, and performance on standardized tests also had a positive correlation. As these variables are not strong enough to be used as single factors, some researchers have shown that a model using both cognitive and non-cognitive characteristics may provide a more promising tool to identify students who may leave engineering or who may benefit from intervention [13,16].

Based on these studies, the selection criteria established to identify prospective students include i) non-cognitive factors such as motivation, meta-cognition, self-efficacy, leadership, learning; ii) and cognitive factors such as high school SAT/ACT score, high school GPA, high school grades in math/science/engineering, and high school number of terms in math/science/engineering. Using these criteria, the Program Director conducts a situational interview based on a systematic analysis known as critical-incident technique. The incidents are turned into interview questions in which applicants are asked how they would behave in a given situation. Cognitive and non-cognitive selection criteria are the optimal mix to prevent the unnecessary bias or exclusion due to single-source assessment or one-size-fits-all test evaluation. The CSEMS program at WSU has benefited 32 undergraduate and 7 graduate students to date. Of the 39 students, 92.3% are African Americans, and 7.3% are Asian Americans. Figure 2 shows the student distribution based on gender and Table 1 outlines the student distribution based on majors.

### 3.3 Program Components

Having analyzed students' needs and identified general program goals, a model for the learning environment was developed. The four primary components identified as factors for success are outlined in Table 2, and discussed in great detail in the remainder of this section.

#### Career Orientation

It has been shown that obstacles to minorities and women participation in engineering include lack of programs and opportunities in authentic science and engineering activities [16]. To address issues pertaining to lack of opportunities for women and minorities, students participate in a career workshop focused on: a) gender and race equity issues for high wage occupations and their roles; b) college preparation and college programs; and c) financial aid and scholarship opportunities. In addition, they also

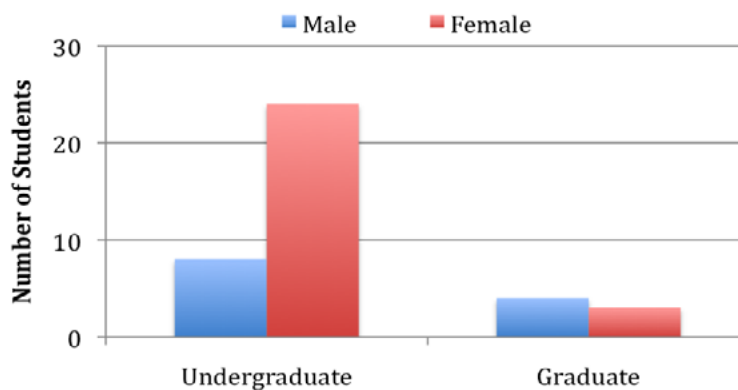


Figure 2. CSEMS students by gender

attend a series of workshops geared towards opportunities and life in college, and meeting key people from the local industry. Table 3 shows an outline of these workshops that occur during the academic year for interested CSEMS participants.

#### STEM Principles

The development and training of competitive women and minority engineers and scientists must focus on a curriculum that can provide self-confidence, enthusiasm, and good problem solving skills. To increase interest and motivation, the curricula must be restructured from teaching theoretical concepts and manipulation of numbers to a pedagogy that is demonstrative and allows practical experience. By using a hands-on approach to learning, students learn and appreciate the fundamental STEM concepts that are essential for the future engineer.

Major	Undergraduate	Graduate
Biomedical Engineering	5	1
Biological Science	2	
Computer Science	5	1
Computer Engineering	2	
Electrical Engineering	3	3
Human Factors Engineering	4	2
Industrial Systems Engineering	3	
Mechanical Engineering	2	
Management Information Systems	5	
Math/Science Education	1	
<b>Total</b>	<b>32</b>	<b>7</b>

Table 1. CSEMS Students by Major

<b>Career Constructs</b>	<b>Related Program Variable</b>
Career Orientation	Commitment to or related research as career Opportunity to pursue STEM career Reasons for pursuing STEM career
STEM Principles	Hands on STEM activities Self-efficacy in STEM disciplines Growth in STEM courses completed Achievement in STEM competency
Academic and Social Support	Role models Counseling Peer study groups Cooperative learning environment
Self-efficacy	Diversity initiatives Peer competency Confidence in performing STEM activities

**Table 2. Linkages between Career Constructs and Program Components**

<b>Workshop - A</b>	Scholarship, Financial Aid, Housing, and Success in College
<b>Workshop - B</b>	Summer Jobs, Internships, and Cooperative Job Experience, and Undergraduate Research Opportunities
<b>Workshop - C</b>	Cover Letter, Resume Writing, and Interviewing
<b>Workshop - D</b>	College Placement Testing, College Orientation, and Retention Skills
<b>Workshop - E</b>	College Experience and Life after College, Meet the Dean of College of Engineering and Computer Science

**Table 3. Career Orientation Workshops**

Also, prior to starting college education, the CSEMS students participate in a one-week math-tutoring program to enrich their math skills and get a jump-start to college. This program provides students with 20 hours of math instruction and reviews the math skills required during the first year of college. Through participation in this program, students get an opportunity to meet upper level and other freshman students, familiarize themselves with the campus, and overall get a jump-start on college life before the academic year starts. At the end of program, students are given a choice to retake the Math Placement Level (MPL) test to improve their scores and register in a higher-level math course accordingly.

It can be observed from Table 4 that the math-tutoring program has had a significant impact with an average of 67% of students improving their MPL scores each year. This resulted in students starting their math course sequence at a higher level than they initially signed up for. Every year, approximately 33% of students had no improvement in their test score, but these students benefited in several ways such as reinforcing their math skills, making new friends, and getting a jump-start to college.

#### *Academic and Social Support*

The support structure for the participating scholarship recipients include math-tutoring program, cooperative education program, stu-

Year	Improved by 3 or more levels (%)	Improved by 2 levels (%)	Improved by 1 level (%)	No change (%)	Decreased (%)
2000	n/a	n/a	n/a	26.31	13.15
2001	12.00	28.00	40.00	12.00	8.00
2002	24.32	18.91	25.67	13.51	17.56
2003	11.29	22.58	38.70	25.80	1.61
2005	15.38	15.38	32.30	27.69	9.23
2006	15.71	20.00	31.42	22.85	10.00
2007	11.32	15.09	34.90	30.18	8.49
2008	13.69	17.8	28.76	28.76	10.95
<b>Average</b>	<b>14.81</b>	<b>19.68</b>	<b>33.10</b>	<b>23.38</b>	<b>9.87</b>

**Table 4. Trend of MPL Scores**

dent research program, and student organizations including professional societies such as SWE and NSBE. SOCHE (Southwestern Ohio Council for Higher Education), a student research program contracts student researchers to Air Force Research Laboratory and Materials/Manufacturing Directorate. Career Placement Office identifies Co-op and internships positions for the students. The Cultural Centers for the African-American, Asian and Hispanic American students help students to network and participate in social and educational programs.

Participation in academic and social programs involves not only knowledge acquisition, but also “*becoming part of the community*” [19]. Building communities for minority and female students in STEM is particularly valuable, as these students tend to feel relatively isolated in programs where they have traditionally been underrepresented.

### *Self-Efficacy*

The goal of CSEMS program is to provide scholarships for women and underrepresented community students to motivate and enable the completion of higher education degrees in STEM fields. The program is in accord with the American Competitiveness and Workforce Improvement Act of 1998 that addresses the national workforce necessity to increase the number of graduates in STEM fields.

During academic STEM workshops, students gain academic experience, and form collaborative learning study groups in which they experience the value of clustering to learn academic survival skills. Teamwork was a common theme across all the various activities, encouraging students to help themselves through the development of peer support and

study networks. Study groups also offer many benefits, including an emphasis on self-support, networking, and the development of communication skills [20-21].

Though students initially enter the program based on their prior performance, they are still required to maintain a minimum 2.5 GPA in order to continue. To demonstrate the importance of the student’s academic performance, whenever the students’ GPA falls below 2.5, he/she is placed on probation, provided additional academic support, and are mandated to meet their advisor periodically. This criterion has proven to encourage students to work hard and maintain a minimum 2.5 GPA while in college.

## **Program Evaluation**

The primary operational measure of effectiveness is the positive attitude students demonstrated towards the CSEMS program as a learning experience. Some of the reasons for this positive response include: a) financial incentive to pursue a degree in STEM disciplines; b) activities that were engaging and meaningful; and c) cooperative learning and networking opportunities.

The effectiveness of CSEMS program can be measured from retention rate and Grade Point Average (GPA). To effectively measure the outcome of CSEMS program, data from all the underrepresented minority students pursuing similar degrees at WSU was collected. Brown et. al [22] in their research has shown that African American students have the least graduation rate of 41.8% compared to any other groups (Hispanic Americans – 64%, and Native Americans-50.7%, and other students-73.1%). Through institutional commitment and support from faculty mentors, the CSEMS program

has attained a graduation rate of 75%, much higher compared to both college and university at 24% and 45% respectively. Of the remaining 25% of students who did not graduate, 12.5% have transferred to a different institution, while 12.5% have dropped out of college. In addition, 20% of CSEMS students who graduated from WSU with an undergraduate degree continued towards a Master's degree. Also, 40% of the CSEMS students were involved in cooperative programs with various corporate and federal entities, compared to a college average of 30%.

With qualitative measure being of equal significance to any support program, the grade point average (GPA) of CSEMS participants has been compared to traditional students of similar background that have not participated in the program. Figure 3 shows the GPA comparison of undergraduate CSEMS participants (n=32) to traditional students that have not participated in the CSEMS program (n=95). While only 63% of traditional undergraduate students have secured a GPA higher than 2.7, 90% of the undergraduate CSEMS participants have secured a GPA higher than 2.7. Similarly, figure 4 shows the GPA comparison of graduate CSEMS participants (n=7) to traditional students that have not participated in the program (n=19). While there is not much difference among the GPA distribution here, it has to be observed that these graduate students are serving as role models for undergraduate students, providing social and academic support necessary towards graduation.

## Conclusions

The CSEMS program provided underrepresented students at Wright State University with a scholarship opportunity, peer support network, and a model to inspire and maintain their determination to commit to high academic standards and graduation in STEM discipline. Overall, the CSEMS program has been successful in meeting its goals of motivating, increasing awareness, promoting a positive attitude, increasing minorities and women participation in STEM disciplines, and improving the performance and retention of students.

The CSEMS program can be used as a model to develop activities for minorities and women, and to develop career intervention programs in areas where underrepresented groups have been traditionally low in numbers. When students' academic and social needs are met, substantial positive outcomes will occur. This program could be well integrated into the insti-

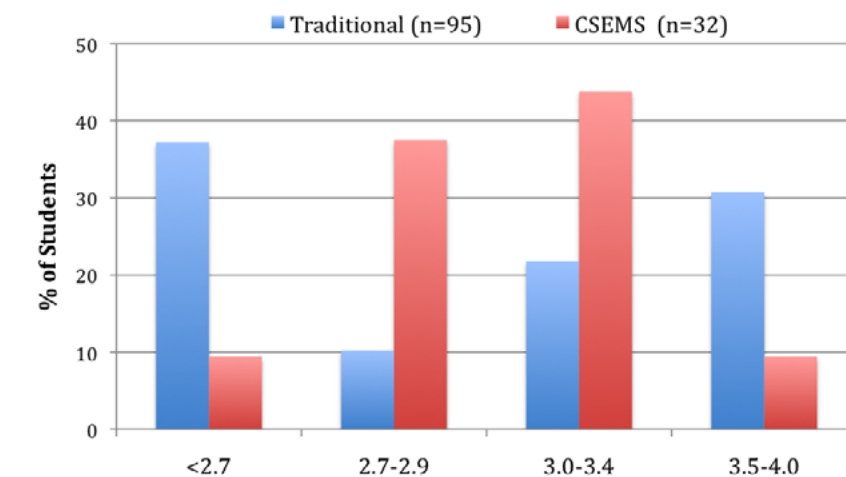


Figure 3. GPA Comparison of Undergraduate Students

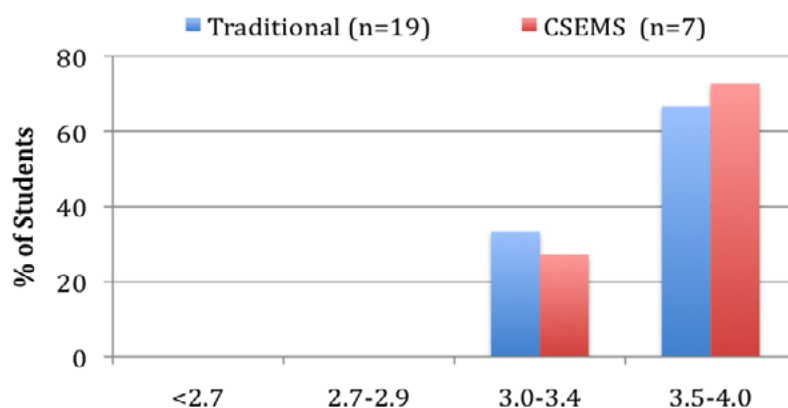


Figure 4. GPA Comparison of Graduate Students

tutional mainstream so that it will be perceived as an overall positive institutional environment. The progress and impact from this program is a good example for other institutions to build a similar support and counseling program for minority and female students.

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