Summer Diversity Program enhances female and underrepresented minority student academic performance and retention in the Drexel University College of Engineering

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Abstract

Women and minority students are underrepresented in the science, technology, engineering and mathematics (STEM) fields. Summer bridge programs may be one way to target this population, and help to ensure academic success and retention in the college years. Over the past three years, the College of Engineering hosted a "pre-orientation" program for accepted incoming students. The program goal was to prepare female and underrepresented minority freshmen for life as engineering students at Drexel University. This program familiarized students with the engineering curriculum and prepared them to succeed in their freshman year through community building and social activities. Program participants showed significant positive outcomes following the program in areas such as problem solving and experimentation, communication, data interpretation and organizational skills. In addition program participant retention was significantly higher than students that did not participate in the program. The authors believe that bridge programs and in particular, the College of Engineering Summer Diversity Program provided incoming female and underrepresented minority freshmen with the academic and social foundation to help them succeed in their engineering education.

Introduction

The Need for Increased Diversity in Science, Technology, Engineering and Mathematics

To maintain the United States' global competitiveness in technology and innovation, we must educate a large, creative technology workforce. The underrepresentation of women and minorities in engineering presents a growing challenge to sustaining our technology leadership. Women comprise more than 50% of earned bachelor's degrees but only 20% of those earned in engineering. Underrepresented minorities make up 28% of the population and are projected to grow to 45% of the population by 2050. Yet African Americans and Hispanics earn only 3-4% of engineering bachelor's degrees[1]. In addition, educating female and minority engineers is essential to economic prosperity within these populations. The science and engineering labor force has grown at an annual rate of 5.9% since 1950, which is nearly five times the total workforce growth rate[1]. Workers in science and engineering fields earn more than double the median earnings of the total US workforce and have lower unemployment rates[1]. Therefore, increasing the number of women and underrepresented minorities in engineering will grow the US technology workforce while increasing earning potential in these populations.

Challenges in Female and Minority Student Enrollment Persistence

Representation of women and minorities in STEM fields has increased over the past few decades but gaps still remain. Since the number of women and minority students who choose to enroll in engineering programs is low, it is critical that those who choose engineering are given every possible opportunity to succeed. The reasons why women and minority student engineering enrollment is low are complex and discussed thoroughly in other work. Briefly, women may be

discouraged from choosing engineering due to the perception that engineering is a male field or the cognitive differences exist between men and women[2]. These perceived gender differences can have a considerable weight on an individual's career or job aspirations[3]. Minorities, both male and female, are less likely to have taken advanced degree classes in high school, which puts them at a disadvantage for being accepted into an engineering major in college[2].

Increasing their persistence throughout their engineering education could enhance the number of women and minorities in the engineering profession. Data from 2009 shows that 3.3% of female students intended to major in engineering yet only 1.4% persisted to earn a degree[1]. Underrepresented minority students, notably African Americans, are less likely to graduate in science and engineering fields compared to members of other racial groups[4, 5]. In engineering, only 32% of African Americans who intended to major in engineering received a degree. Many minorities who leave engineering may not persist to any undergraduate degree. Among students who entered STEM undergraduate majors, 35.2% of Black students and 31.6% of Hispanic students left postsecondary education without any degree (STEM or otherwise) compared to 24.6% of Caucasian students[6]. Part of the racial disparity in STEM persistence may be linked to inequalities in primary and secondary education[7], including K-12 teacher quality, curriculum, class size and school size[8].

Strategies for Success: Summer Bridge Programs

Proactive university support and commitment can help women and minorities integrate and persist throughout their engineering education[4, 9]. During the academic year, tutoring and study centers can improve student preparation, commitment, and engagement, which enhances retention and graduation rates[5]. Students also benefit greatly from combined academic and social integration[5, 10, 11]. Successful retention programs emphasize counseling resources, social support and community membership[5, 12]. In addition, counselors who are of the same racial group of the minority students tend to reduce isolation for minority students who use social support and counseling services[13].

Outside of the academic year, summer bridge programs address the challenging transition from high school to college[4]. Existing summer bridge programs provide academic support, mentorship and a sense of community to enhance student long term success in college and the engineering field. A five week long Georgia Tech summer bridge program focuses on math, science, and English coursework and includes an academic mentorship and social component. The National Science Foundation supported Louis Stokes Alliances for Minority Participation (LSAMP) Summer Scholars program at Oregon State is focused on increasing the underrepresented minority student retention rate in STEM related majors by creating a community of diversity. Purdue University runs a five week Academic Boot Camp Program through which multi-ethnic accepted students are exposed to coursework, lifestyle, and the pace of college life. Students take a variety of specially designed courses that aim to help students understand where their strengths and weakness lie and where they can receive academic help if needed.

Little data is available on student demographics or retention outcomes for summer bridge programs; however, a few studies do show improved retention for summer bridge participants. A study of 617 students who participated in the Georgia Tech summer bridge between 1990 and

2000 found that underrepresented minority students who participated in the program were 19% more likely to graduate than their underrepresented minority peers who did not participate in the program [5]. African American, Hispanic, and Native American student who participated in Purdue's Academic Boot Camp showed higher retention rates and first semester grade point averages[14].

Institution Overview and Program Objective

The College of Engineering is the largest college within Drexel University, a large urban University located in Philadelphia, Pennsylvania. The College of Engineering supports students in 5 engineering disciplines (Chemical and Biological Engineering; Civil, Architectural, and Environmental Engineering; Electrical and Computer Engineering; Materials Science and Engineering; Mechanical Engineering and Mechanics). In 2013 nearly 1100 students joined the College of Engineering Freshman class. Female students composed approximately 21% of the incoming class and approximately 9% of the incoming class was African American and Hispanic students (Table 1). The Summer Diversity program is the only program within the College of Engineering that specifically targets underrepresented minority students and women. The Summer Diversity Program objective is to provide support for women and underrepresented minority incoming freshmen, with the goal of increasing retention through their first year and persistence to graduation.

Table 1: Race and Ethnicity Distribution in the College of Engineering 2013 Incoming Freshman Class

Race	Count
American Indiana or Alaska Native	2
Asian	166
Black or African American	48
Hispanic	52
Native Hawaiian or Other Pacific Islander	11
Nonresident Alien (International)	196
Race and Ethnicity Unknown	13
Two or More Races	29
White	580
Total	1097

Summer Diversity Program Overview

Low female and minority enrollment and persistence in science and engineering results from a combination of complex issues, including K-12 mathematics and science education, access and motivation, college affordability, and academic and social support[15]. Since the pipeline flow is low, it is crucial to ensure that those female and minority students who choose to pursue engineering degrees have the support and resources that they need to be successful. Over the past three years, Drexel University College of Engineering hosted a Summer Diversity Program for

accepted incoming students. The goal of this program is to provide academic and social support to help women and minority students who choose to become engineers persist through their first year and beyond. The program originally was one week long; however the program was expanded to two weeks in the second year to include more core content and to accommodate student requests for a more relaxed schedule.

Recruitment

Since the Program is focused on diversity, women and underrepresented incoming freshmen students of all academic levels were invited independent of their academic preparation. The program director emailed all women and underrepresented minorities in the College of Engineering incoming freshman class in the late spring. 71, 147, and 196 students were invited to the program in 2011, 2012, and 2013 respectively. The variation in invited student numbers was due to the targeted majors and international student inclusion. International students were included in the 2013 cohort, since they appeared to benefit from extra academic preparation, confidence building and community engagement in a similar way to domestic students. Male students with weaker academic preparation were not included, since the University has existing programs for students with lower academic preparation. Asian American students were not invited to participate in the program because they are not unrepresented within the College of Engineering.

Students submitted an application with questions such as, "Why are you interested in engineering?", "What would you like to do in your engineering career?", and "What is the biggest challenge in the world today that engineers can help solve?" Students listed the biggest engineering challenges as creating more efficient transportation, upgrading infrastructure, and developing renewable energy. Additional questions asked about the students' perceived academic strengths, weaknesses, and apprehension about their freshman year. Students noted that they were good problem solvers, excelled at math and science, liked to use logic, and worked well with others. Weaknesses included language arts, reading and writing, and maintaining a good balance. Students were also required to pay $500 to cover part of the program costs. Applications were reviewed and participants were notified via email of their acceptance. All students who applied were accepted into the program.

Program Schedule

Students arrived on campus the Sunday prior to the program start. That evening, they met with each other and student mentors at a Welcome Dinner. Each morning, the students studied math, chemistry, and physics. A faculty member who teaches the freshman level course in that subject taught each class. The academic focus for each course was a review of essential high school material, including pre-calculus, basic chemical reactions, and Newtonian physics, needed for success in the college level course. Students attended evening recitation sections to receive extra help with problem sets, and each course had at least one test to evaluate student learning progress and accustom students to the pressures of college exams.

During the afternoon, the students participated in hands-on design and computer labs to familiarize them with important computer software and increase their comfort with engineering

design. Specifically, the students learned Matlab, Creo, and Microsoft Excel and Powerpoint. In the first module, they built solar cars. This module was selected because the students expressed interest in alternative energy, and it was an ideal platform to provide students with both hands-on and computational design and building experience. Specifically, the students characterized the solar panels, built an existing solar car design, created their own solar car design, and drew their solar car designs in Creo computer aided design software. They then presented their results to the other student teams. In the second module, the students programmed Lego NXT robots and competed in a Sumobot challenge. This module was selected to prepare the students for a similar module in the freshman design course. The afternoon courses were coordinated and taught by graduate students, who were selected because they were top teaching assistants in the Drexel freshman engineering curriculum. When possible, female and minority students were selected.

In the evenings and during the weekend, the students socialized with current Drexel Engineering faculty and students and participated in social activities to build community and discover opportunities both at the University and in Philadelphia. Department heads and advisors met the students during Introduction to Engineering at the College, the Society of Women Engineers hosted a barbeque, and peer mentors took students to activities throughout the city, including tours and miniature golf. Social activities provided a means for students to interact with each other in a casual, non-competitive way while also experiencing cultural and historical sites and familiarizing themselves with a new area. The program concluded with a celebration at a baseball game. Past participants of the program and members of engineering focused clubs and organizations at the College were often invited to these events as a way to serve as casual mentors for the program participants. See Table 2 for detailed program schedule.

Table 2: 2013 Program Schedule

Sunday *8/4*	**Monday** *8/5*	**Tuesday** *8/6*	**Wednesday** *8/7*	**Thursday** *8/8*	**Friday** *8/9*	**Saturday** *8/10*
	9:00 - 10:30 Math	*9:00 - 10:00* Math	*9:00 - 10:00* Math	*9:00 - 10:00* Math	*9:00 - 10:00* Math Exam	Schuylkill River Boat Tour
	10:30 - 11:30 Eng Campus Tour	*10:00 - 11:30* Chemistry	*10:00 - 11:30* Chemistry	*10:00 - 11:30* Chem Recitation	*10:00 - 11:30* Chemistry	
	11:30 - 1:00 Lunch with TAs	*11:30 - 1:00* Lunch	*11:30 - 1:00* Lunch with faculty	*11:30 - 1:00* Lunch	*11:30 - 1:00* Lunch with faculty	
	1:00 - 2:00 Study skills	*1:00 - 2:30* Physics	*1:00 - 2:30* Study skills	*1:00 - 2:30* Physics	*1:00 - 2:30* Physics Exam	
	2:00 - 4:30 Intro to Engr & Design Process					
2:00 - 4:00 Check in	Act: Solar Panel Characterization EXCEL	*2:30 - 5:30* Intro to technical drawings. Sketch team design	*2:30 - 5:30* Continue drafting solar car in Creo. Building solar car	*2:30 - 5:30* Powerpoint presentations Building Time & Testing	*2:30 - 5:30* Finalize Mini-Presentations Solar car race	
	4:30 - 5:30 Eng at Drexel Dept heads	Intro to Creo Create Part			Design Presentations & Peer Review	
5:30 - 7:30 *Welcome Dinner*	*5:30 - 6:30* Dinner	*5:30 - 6:30* Dinner	*5:30 - 6:30* Dinner	*5:30 - 6:30* Dinner	*5:30 - 6:30* Dinner	*Dinner on your own*
	Evening *Philadelphia Tour*	*Evening* Math recitation	*Evening* Physics recitation	*Evening* Math recitation	*Evening* Rock Climbing	

Sunday 8/11	Monday 8/12	Tuesday 8/13	Wednesday 8/14	Thursday 8/15	Friday 8/16	Saturday 8/17
Mini-golf at Franklin Square	*9:00 - 10:00* Math	*9:00 - 10:00* Math	*9:00 - 10:00* Math	*9:00 - 10:00* Math Exam	*9:00 - 10:00* Math	*Depart*
	10:00 - 11:30 Chemistry	*10:00 - 11:30* Chem Recitation	*10:00 - 11:30* Chemistry	*10:00 - 11:30* Chem Exam	*10:00 - 11:30* Chemistry	
	11:30 - 1:00 Lunch with TAs	*11:30 - 1:00* Lunch	*11:30 - 1:00* Lunch with faculty	*11:30 - 1:00* Lunch with sponsor	*11:30 - 1:00* Lunch with faculty	
	1:00 - 2:00 Study skills	*1:00 - 2:30* Physics	*1:00 - 2:30* Study skills	*1:00 - 2:30* Physics Exam	*1:00 - 2:30* Physics	
	2:00 - 4:30 Introduction to Matlab Worm or Robot Programming Challenge	*2:30 - 5:30* Intro to NXT Robots Build Robot with light sensor Intro to sensors Program robots to trace shapes, follow line	*2:30 - 5:30* Intro to flow diagrams and closed loops Draw flow diagram for robot maneuver around obstacle Design Challenge Rules & Guidelines Program Sumobots	*2:30 - 5:30* Build Sumobots Preliminary Sumobot Challenge	*2:30 - 4:30* Presentations Final Sumobot Challenge	
	4:30 - 5:30 Eng at Drexel Student Orgs				*4:30 - 5:30* Alumni social	
Dinner on your own	*6pm* SWE BBQ	*5:30 - 6:30* Dinner	*5:30 - 6:30* Dinner	*5:30 - 6:30* Dinner	*6:00 - 10:00* Farewell Dinner *Camden Riversharks*	
	Evening Free	*Evening* Physics recitation	*Evening* Math recitation	*Evening* Free		

Budget

The program's corporate sponsors paid for the majority of the program's costs. Program participants paid their transportation to and from the University and also were asked to pay $500 to secure their space in the program and demonstrate commitment to attending. Each year approximately 10% of the participants asked for financial assistance and their $500 fee was reduced based on the student's financial aid record. Main costs associated with the program included housing, meals, faculty and TA stipends, and events (Table 3).

Table 3: Program Budget

Costs	
Social Activities	
Welcome Dinner	$900
Philadelphia Tours	$1,050
Rock Climbing	$150
Final Event: Baseball Game	$2,750
Other Activities	$600
Housing and Meals	
Dining Hall	$5,500
Housing	$10,000

Faculty and TA Payment	
Faculty	$10,000
Teaching Assistants	$6,000
Laboratory Supplies	
Solar Cars	$1,000
Miscellaneous Supplies	$500
Total Cost	$38,450
Revenues	
Corporate Contributions	$33,000
Student Payment	$9,000
Total Revenue	$42,000

Assessment

Students were evaluated using quantitative and qualitative data. Students completed surveys based on the National Engineering Students' Learning Outcomes Survey at the start and end of the program. Each year the survey questions varied slightly to reflect unique changes made to the program or new labs that were introduced. Student's grade point averages (GPAs) and retention rates were also used as a form of assessment. The program participants GPAs and retention rates were compared against women and minority non-participants and with College of Engineering students as a whole.

Program Outcomes

Program Participants

In year one (2011) 18 students participated in the program. 14 of these were women, and 4 were underrepresented minorities. In year two (2012) 26 students participated in the program; 14 of the participants were women, and 14 were underrepresented minorities. In year three (2013) 22 students participated in the program; 13 of the participants were female, and 13 were underrepresented minorities. Students who declined to participate in the program will be surveyed in the future to determine why some students choose to participate and others do not.

Survey Results

Each year, students showed significant positive outcomes following the program. In 2011 students showed the largest improvement in evaluating problems and recognizing contemporary issues in the science and technology fields. In addition students also reported strong knowledge and understanding of their post-graduation goals and the steps required to achieve those goals. In 2012, participants felt that the program helped them solve open ended problems, improved their understanding of computational and numerical tools needed to solve programs, and improved their ability to use feedback from an experiment to create improved solutions. In 2013, problem solving, product and system design, and communication showed the highest reported increases. In the post survey, students also wrote general comments about what they liked and disliked about the program. Students felt the program provided them with an accurate "taste of college", made them feel like they "had an advantage over other freshman" through their participation and meeting freshman year professors early, allowed them to "meet new friends", "make connections with upperclassman, TAs and faculty", and "become familiar with campus". Students also indicated the bus tour and other off campus activities were some of the most enjoyable social components. The two main reported dislikes were the "tedious schedule" and "mandatory group activities." Students also comments for program improvement included: more study skills session, less required evening activities, and more breaks throughout the day. All participants indicated that they would recommend the program because they met alumni who could help in the future, made friends, helped review materials for the upcoming year, and learned to be independent.

Grade Point Averages (GPAs)

Program participants' GPAs were at or above average. Students entering Drexel University College of Engineering in Fall 2011 averaged a 2.89 GPA (+/– 0.77) following their second year. 2011 program participants who were still enrolled at the University at the end of year 2 had a 2.87 GPA (+/- 0.49). A similar pattern holds for 2012. Drexel College of Engineering students entering in Fall 2012 averaged a 2.92 GPA (+/– 0.75) following their first year. 2012 program participants had a 3.05 GPA (+/– 0.63) following their first year (Table 4). These data suggest that program participants' GPAs were the same—and probably higher—than that of Drexel College of Engineering students overall.

Table 4: Drexel College of Engineering Students GPA and Program Participant GPA

	College of Engineering	Program Participants
2011	2.89 (+/- 0.77)	2.87 (+/- 0.49)
2012	2.92 (+/- 0.75)	3.05 (+/- 0.63)

Retention

Program participant retention was also higher than the average. The Drexel College of Engineering retention rate is 76.8% from freshman to sophomore year and 68.3% from freshman to pre-junior (3rd) year. For female and underrepresented minority students who were offered acceptance to the program but did not participate, the retention rate was 78.5% from freshman to sophomore year and 62.1% from sophomore to pre-junior (3rd) year. Program participant retention was 92% after year one and 83% after year two (Table 5). This indicates that the

students in the program were more likely to stay at the University and in the College of Engineering compared to their counterparts and the college population overall. While the specific reasons for increased retention are unknown, we believe that increased academic preparation coupled with peer mentorship provided the program participants skills, knowledge and support that aided in their persistence.

Table 5: Retention Rates for College of Engineering Students, All Women and Underrepresented Minorities, and Program Participants

	College of Engineering	All Women and Minorities	Program Participants
2011	68.3%	62.1%	83.0%
2012	76.8%	78.5%	92.0%

Conclusion

In conclusion, the Drexel College of Engineering Summer Diversity Program aimed to provide incoming female and underrepresented minority freshmen with the academic and social foundation to help them succeed in their engineering education. Student survey responses indicate that the program was successful at improving individual skills such as problem solving. Retention rates for program participants were higher than non-program participants as well as higher than College of Engineering students as a whole and this is especially noteworthy from sophomore to pre-junior year. Although there are other variables to consider, these data indicate that the two-week Summer Diversity Program may have provided students with an academic and social advantage that has helped them to succeed at Drexel University.

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