The Study of the Effectiveness of Scholarship Grant Program on Low-Income Engineering Technology Students

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Abstract

This paper investigates the effectiveness of a National Science Foundation Scholarship in Science, Technology, Engineering, and Mathematics (NSF S-STEM) program named "Scholarship for Engineering Technology (SET)" at the State University of New York in Canton (SUNY Canton). The authors seek to answer the following question: To what extent will a scholarship grant program help increase the number of low-income and under-represented students attaining college education and continuing to graduate school or the workforce. The low-income students in this study were mostly first-generation college students, sixty percent of whom were under-represented groups (women and ethnic minorities). The authors were motivated to perform this grant study due to the low number of women and ethnic minorities at SUNY Canton's School of Engineering Technology; and the region (St. Lawrence County) being one of the most economically depressed regions in northern New York state. The findings indicate that a scholarship and academic support program enhanced the achievement rate and promoted access and persistence of the cohort of students in this SET program, without which many of the students may not be able to attain college education in STEM and are more likely to drop out.

Introduction

This paper presents the findings of the study designed to understand the impact of a National Science Foundation Scholarship in Science, Technology, Engineering, and Mathematics (NSF S-STEM), the SET (Scholarship for Engineering Technology) program at the State University of New York in Canton (SUNY Canton) on low-income women and ethnic minority students. In 2010, SUNY Canton received NSF S-STEM grant (award number 0966003) for $596,160 to support 18 low-income and academically talented students to pursue and complete a baccalaureate degree and/or associate degree in its school of engineering technology programs (Mechanical Engineering Technology, Civil Engineering Technology, Electrical Engineering Technology, Alternative and Renewable Energy Applications, and Engineering Science). Each SET scholarship recipient received $7,200 per year for up to four years ($28,800). The program also provided academic and enrichment support services to enable the scholars to succeed. It offered mentoring program, tutoring services, STEM seminars, a summer program to boost scholars' physics and mathematics backgrounds, field trips, and professional development opportunities such as conference attendance. SUNY Canton is a four year college of technology that has established a tradition of excellence with respect to its educational mission. It offers one, two, and four year academic programs along with academic minors that enable students to refine and further elevate their career goals. SUNY Canton is located in Saint Lawrence County, one of the counties in the economically depressed region of rural northern New York state, and often referred to as the "North Country."

The SET program scholars were selected based on specific standard criteria. The criteria are: 1) Citizen or Permanent Resident of the United States; 2) Admission at SUNY Canton's School of Engineering Technology; 3) Demonstrated academic potential; 4) Demonstrated financial disadvantage; 5) Two letters of recommendation; 6) An essay not less than 500 typed words about their life, accomplishments, and the future they would like to build for themselves, their family, and their community. Underrepresented groups (first-generation, women and ethnic minorities) meeting criteria were given preference.

In this study, the impact of the SUNY Canton SET program strategies were examined and the results detailed in terms of retention rates, GPAs, and the promotion of access and persistence in engineering. Some of the lessons learned and drawback/constraints were discussed.

STEM Education for Low-Income, First-Generation, Women and Ethnic Minorities: The Problems

In a publication by the US Department of Education, NCES 2005-171 [1], it was found that first-generation students are at a distinct disadvantage in gaining access to post-secondary education, and even more so in STEM field. In addition, those who overcome the barriers and enroll are more likely to drop out compared to their peers whose parents have a college education [2 – 4]. Statistics from SUNY Canton students' information data and enrollment show that in the fall of 2007, student enrollment was 2,737, with 1,419 (52 percent) females and 1,318 (48 percent) males. However, the school of engineering technology, one of the four schools in the college, has 528 students of which only 45 (8.5%) are females and 483 (91.5%) are males. In addition, only 6% of the students in the school of engineering technology are from underrepresented groups. This is a pure indication that fewer women and underrepresented ethnic minorities choose careers in engineering and technology. Women have been traditionally underrepresented in science and engineering [5, 6]. Gibbons [7] indicated that the graduation rate of women from engineering programs is declining and women only make up 18 percent of the engineering workforce [8]. Ethnic minorities are also traditionally underrepresented in science and engineering. In a paper [9], "Increasing Diversity in Engineering Academics (IDEAs)," it was found that engineering is one such area where African Americans, Hispanics, and Native Americans have been traditionally under-represented. Studies [10, 11] show that under-represented racial minorities earn college degrees in STEM fields at a lower rates than do their majority peers and earn around 20 percent of the engineering bachelor's degrees and only represent around 10 percent of the engineering workforce. Underrepresented groups are needed for diversity. According to the US Code – Section 1067: Congressional Findings, "As the Nation's population becomes more diverse, it is important that the educational and training needs of all Americans are met; underrepresentation of minorities in science and technological fields diminishes our Nation's competitiveness by impairing the quantity of well-prepared scientists, engineers, and technical experts in these fields" [12]. In the book "Talking About Leaving, Why Undergraduates Leave the Sciences" [13], nationally, 40 percent of undergraduate students leave engineering programs, and the losses are disproportionately greater among women and minorities. In addition, studies [14 – 20] found that under-represented minorities in Science, Technology, Engineering, and Mathematics (STEM) fields dropout at substantially higher rates than other groups.

Research [21, 22] consistently points to insufficient financial resources as one of the factors/reasons low-income and under-represented students dropout or transfer out of their STEM undergraduate field of study. However, studies have shown that financial support alone is not sufficient. A study of Georgia's College Scholarship program [23], the HOPE (Helping Outstanding Pupils Educationally) scholarship program, through its state's lottery revenue, provided Georgia State high school graduates who have a B average free tuition and a modest book allowance at the state's public colleges and universities. However, this was just monetary support and did not include academic support piece. It was found that roughly half of HOPE scholars lost their support at the end of their freshman year [23, 24]. It was also found that students in STEM field were 21 to 51 percent more likely to lose their funding than similar qualified students in other fields. This is evidence that monetary support alone (scholarship) is insufficient, especially for the low-income, first-generation, minority and/or women to succeed in STEM fields.

Scholarship for Engineering Technology (SET) Program: Cultivating Success

The implementation of the SUNY Canton SET program incorporated evidence-based methodologies and best practices based on literature [25 – 39]. The SET program provided scholarship (monetary support), in addition to academic and enrichment support services to enable the scholars to succeed. The support services include monitoring, mentoring, tutoring, summer program, field trips, and conference attendance/professional development. The advantages of these activities are significant and provide opportunities for students to further develop their skills and reinforce the basic principles of active learning. For example, a summer program in math and physics implemented in the SET program is an opportunity for our scholars to further develop their skills in keys areas. There has been a great deal of evidence from research analyzing the effectiveness of "summer bridge programs" with respect to bridging the opportunity gap to improve retention and success in college level math courses. J. Gleason et. al [31] observed significant increases in student retention in STEM fields – in some cases up to 36%. Mentoring is another feature of importance particularly for women in engineering and students from under-represented groups. In [32] the authors review the benefits of faculty mentoring of students in higher education and identify successful strategies and best practices. Also in [33], the authors found that "improved mentoring of women can have a significant impact on their careers, lives and more generally, on their academic climate." According to Bettinger and Baker [34], mentoring students once in college can increase persistence and completion, and in addition, they found that one-on-one coaching increases college graduation rates by 4 percent. Naomi C. Chesler and Mark A. Chesler [33] found that improved mentoring of women graduate students and young faculty is one strategy for increasing the presence, retention, and advancement of women scholars in engineering. Conference attendance is another activity that has helped to build network and confidence in students. The authors in [35] found that conference attendance helps students keep abreast of current developments in their fields and fosters the development of a social network of technical professionals, which stretches beyond their own institution. The importance of a support program cannot be overemphasized.

Supporting the SET program, STEM-based efforts are established modeling STEM-based programs [36 - 39] with similar objectives targeting minorities and women with common key components of summer bridge programs which include an essential math "course", mentoring, excursions to STEM related sites, recurring social events, and ongoing intervention programs for academic monitoring that have persisted/flourished for 10 years or more. In a study [36] on a University of Maryland Baltimore County STEM-based program, it was found that the under-represented students (Meyerhoff scholars) achieved higher grade point averages, graduated in science and engineering at higher rate, and gained admittance to graduate schools at a higher rate than multiple current and historical comparison samples. In another study [37] on the Academic Investment in Math and Science (AIMS) program at Bowling Green State University, the author reported outstanding retention of AIMS students at the University and in the STEM fields with a retention rate of 93% after the first year, and 89% in the final year. The author noted that a balance of activities through the four years in college must be in place to sustain positive momentum and facilitate commendable progress toward graduating. A University of Akron ten-year assessment of pre-engineering program for under-represented, low-income and/or first-generation college students [38] showed similar higher achievements.

The SET program provided the scholars with academic and enrichment support services, which included:

1. Welcome Meeting, Orientation and Social. Every semester, the SET program held welcome meetings and socials during the second week of the semester requiring attendance of all scholars. During the meetings, the goals, objectives and activities planned for the semester, and requirements and expectations of the scholars for the semester/year were discussed.
2. Mentoring Program, Assessment and Monitoring. The scholars all have their departmental academic advisors. In addition, the scholars have SET program mentors. The SET management team/advisors/mentors were assigned about 3 to 4 scholars each to mentor and monitor their academic progress. Scholars met with their SET program mentor/advisor twice every semester and as needed. During the meeting, the scholars turn in academic instructors' progress reports from all their course instructors. Progress reports allow students to develop a relationship with their instructors and to use the progress report as an assessment tool to make the necessary adjustments in their courses. This progress report is required of all scholarship recipients early in the semester for immediate intervention requiring tutor assignment as needed and later in the semester. The meeting is also to discuss performance and ways for improvement. Moving Towards Success (MTS) was implemented. MTS is a college wide monitoring instrument used to monitor students early in the semester to determine students struggling for early and adequate intervention. Midterm and final grades were also reviewed by SET advisors/mentors.
3. SET Program Supplemental Tutoring and Peer Tutoring. Two Professional tutors were hired every semester specifically for SET program scholars. In addition, peer tutors were employed as needed.
4. SET Program Seminar and Monthly Social. The SET program had monthly STEM seminar with invited guest speakers and monthly socials. The STEM seminars were open to the campus community and free.
5. Professional Development Activities. SET scholars attended several conferences and workshop trainings. The conferences provided professional development experiences and networking for the SET scholars. The following are some the conferences and workshops attended by our SET scholars. The 2016 ASEE (American Society for Engineering Education) Annual Conference and Exposition in June 2016; the Women and Minority Adult Conference at SUNY Empire State College in April 2014; the SUNY STEM Conference in October 10 – 11, 2013 (Albany, NY); and training and career workshops. The SET program provided opportunities for conference attendance, building moral and confidence, and networking in the scholars' STEM education.
6. Annual Field Trips. The SET scholars had a series of annual educational field trips. The field trips include: 1) Visit to the Department of Energy's Brookhaven National Laboratory in Upton, New York; 2) Visit to Kennedy Space Center in Florida; 3) Visit to Rochester Museum of Art and Science, among others.
7. SET Summer Program in Math and Physics. The summer program in Math and Physics were conducted in the first three years of the program. The scholars were provided with hands-on activities in math and physics in order to prepare and provide them with adequate background for the coming

semester. As a result, 74 % of the scholars received a minor in math and/or applied physics.

Promotion of Access and Persistence

This study looked into the effectiveness of scholarship grant in promoting access for low-income and academically talented students in attaining a college education. Access to the opportunity to attend college and/or opportunity to participate in career building programs. According to Fife and Leslie [40], equal access exists when all those who desire and qualify to attend college are able to do so, while inequality, on the other hand, suggests the presence of persons who qualify to enter college and would do so but for lack of funds. To determine if the SET program was a factor in promoting access, scholars were surveyed about their first semester of the SET program and its influence on their decision to attend college. The scholars overwhelming indicated that the SET program influenced their decision to attain a college education, attend SUNY Canton, and/or chose a career in Engineering Technology (STEM field). This scholars' perception is an indication that the SET program was instrumental to promoting access for low-income students. Similar findings have been reported elsewhere [40]. Continuing to promote access, a tutoring center was developed specifically for SET scholars supported by the SET grant for one-on-one tutoring. The developed tutoring center using this grant is now institutionalized and expanding access.

To gauge the scholars' persistence and perception of the opportunities provided by the SET program components, scholars were surveyed at the end of their first SET summer program in Math and Physics. Scholars were asked if they really enjoyed the summer program and if the program activities/workshops make them want to learn more. Table 1 shows the survey questions and scholars response. A similar survey was given to the scholars throughout the grant period on most of the SET program activities to gauge their perception. From Table 1, ninety percent of the scholars agree or strongly agree that they enjoyed the summer program in Math and Physics; which is the perception of engagement, and all the scholars (100%) said the summer program in Math and Physics made them want to learn more, which is an indication of persistence.

The Impact of the SET Program: Significant Results

The total duration of the SUNY Canton SET program was six years (9/1/2010 to 8/31/2016). We had two cohorts of students: The first cohort of 18 scholars recruited in the first year by fall 2011; and the second cohort of 12 scholars who were recruited to replace any of the first cohort scholars who had graduated with an Associate's degree or left the program. In total, 30 students participated in our SET program, and 60 percent (18) of these 30 students were from under-represented groups. The impact of the program was measured in terms of retention rates and GPAs of the participants.

Survey Questions	Answer Options	Students Response
(1) I really enjoyed the summer program in Math and Physics.	(1) Strongly Agree (2) Agree (3) Disagree (4) Strongly Disagree	30 % Strongly Agree 60 % Agree 10 % Disagree
(2) Did the workshop activities make you want to learn more?	Yes or No	Yes ------100 %

Table 1: Survey Questions and Scholars' Response upon the Completion of the First SET Summer Program in Math and Physics.

Overall, we retained and graduated 23 students of the 30 total participants in the program, which is a 77 percent retention rate. Out of these 23 retained scholars, 17 (74 %) graduated with a Bachelor's degree and six (26 %) graduated with an Associate's degree. Among the 60 percent (18 of 30) of the under-represented group of students in the program, we retained and graduated 89 percent (16 of 18). Table 2 presents these results. In addition, Tables 3 and 4 show the outcome results in cohorts. The GPA analysis of the outcome of the scholars are shown in Figures 1, 2, and 3. Figure 1 is a graph showing the GPA (first year and last year in the program GPAs) of the 17 students who graduated with Bachelor's degree. The graph shows that out of these 17 students, only one student had a GPA that was below 3.0, but in the upper 2.0s and many of the students had GPAs approaching 4.0. Figure 2 is a graph showing the GPA (year one and year two GPAs) of the six students who graduated with an Associate's degree. Of the six who graduated with an Associate's degree, three transferred out and continued in STEM

• Number of scholarship recipients: 30 scholars over a six-year period
• Percent of recipients graduated/retained: 77% (23 scholars)
• Percent of graduated/retained recipients receiving Bachelor's degree: 74% (17)
• Percent of graduated/retained recipients with Associate's degree: 26% (6)
• Percent of graduated/retained recipients earning minor in Physics and/or Math: 74% (17)
• Percent of under-represented (women and ethnic minorities) scholarship recipients: 60% (18 of 30)
• Percent of graduated/retained under-represented scholarship recipients: 89% (16 of 18)

Table 2: Overall outcome of all S-STEM scholars over six-year period

• Number of scholarship recipients: 18 scholars
• Percent of recipients graduated/retained: 72% (13 scholars) within four year
• Percent of recipients who left the program: 28% (5 scholars; all were replaced)
• Percent of the 13 graduated/retained recipients receiving Bachelor's degree: 54% (7)
• Percent of the 13 graduated/retained recipients with Associate's degree: 46% (6 scholars; 3 transferred to other schools and were replaced)
• Percent of the 13 graduated/retained recipients earning minor in Physics and/or Math: 54% (7 scholars: 6 with bachelor's degree and 1 with associate's degree)

Table 3: Outcome of the first cohort of 18 scholars enrolled in the planning year 2010/2011

• Number of scholarship recipients in this cohort: 12 scholars
• Percent of recipients graduated/retained: 83% (10 scholars)
• Percent of recipients who left the program: 17% (2 scholars)
• Percent of the 10 graduated/retained recipients receiving Bachelor's degree: 100%
• Percent of the 10 graduated/retained recipients earning minor in Physics and/or Math: 100%

Table 4: Outcome of the second cohort of 12 scholars used as replacements as needed

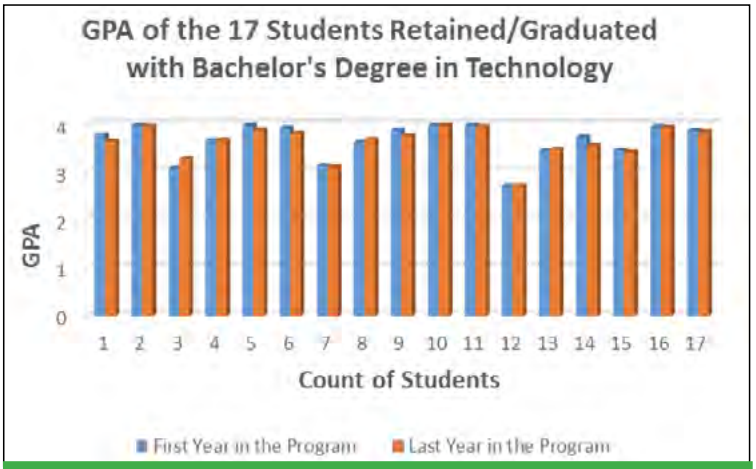

Figure 1: Bar graph showing students earning bachelor's degree and their GPAs

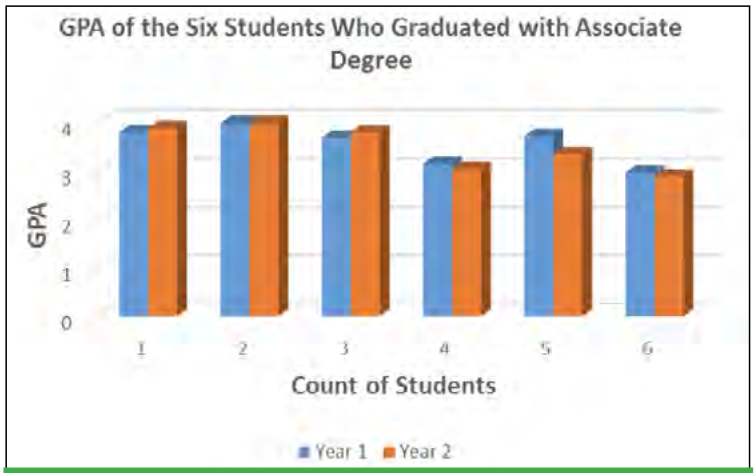

Figure 2: Bar graph showing students earning Associate degree and their GPAs

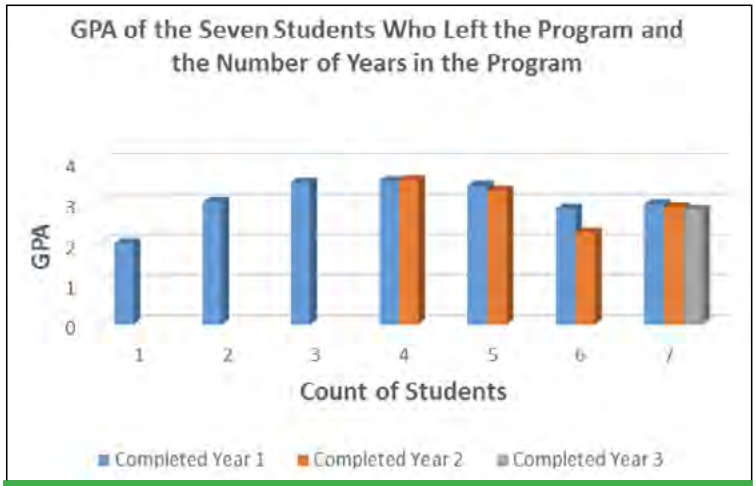

Figure 3: Bar graph showing students who left the program and their GPAs

field for a Bachelor's degree (and were replaced) and three continued on the S-STEM program for a Bachelor's degree at SUNY Canton. Figure 3 shows the graph of GPA of the seven students who left the program. The data shows that student numbers 1, 2, and 3 left the program at the end of their first year in the program; student numbers 4, 5, and 6 left at the end of their second year in the program and the seventh student left at the end of his third year in the program. It is to be noted from figure 3 that only two students (1 and 6) left the program due to poor academic performance. Students 2, 3, and 4 transferred out, while students 5 and 7 left due to other reasons.

Lessons Learned and Program Constraints

We found that the recruitment of cohort of scholars with different academic backgrounds was our biggest challenge as they do not all graduate at the same time, extending the program to six years and making the management of the program a bit more complicated. Specifically, our cohort included incoming freshmen pursing Associate and/or Baccalaureate degrees in Engineering Technology programs, along with some transfer students. We learned not to combine baccalaureate, associate, and transfer students all in one cohort. It is better to do one of each as a cohort (i.e., recruit cohorts of incoming freshman at the same academic level for baccalaureate degrees only, or associate only, or transfer only). Another constraint was the difficulties in finding days and times for SET program activities/meetings, due schedule conflicts. Nevertheless, the institution overcame this general problem by setting aside Tuesday and Thursday noon to 1:00 pm across the campus with no class scheduled at this time.

Conclusions

The presented information does not represent a complete solution and we are not illusive to that. The authors document their formative findings as we continue to improve diversity in STEM education. Our studies have shown that both scholarship and academic/enrichment support programs are essential to reducing attrition for low-income, first-generation, women and minority students especially in STEM field by providing needed access for these students. The project had a great impact on the principal field of engineering technology; and in physics and math. It produced twenty-three (23) educated and skilled graduates with bachelor's and/or associate's degree within the discipline of engineering technology. In addition, the cooperative summer program in physics and mathematics implemented in the project added to the fields of Physics and Mathematics. Seventy-four percent (74%) of our SET graduates earned a minor in Applied Physics and/or Mathematics.

This SET project targeted low-income students,

women and ethnic minorities. The effort yielded 60 percent (18 of 30 SET scholars) minority students in the program with an 89 percent retention rate of this group. Our SET program therefore, produced a diverse set of skilled graduates going into the workforce in technical fields. Beyond the bounds of science, engineering, and the academic world, this project has impacted the society. SUNY Canton is located in Saint Lawrence County, one of the counties in the economically depressed region of rural Northern New York State often referred to as the "North Country." Some of our scholars are first- generation in their families to go to college. This project has impacted the society by helping to meet local needs and provide services that enabled the scholars to attain higher heights.

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