S-STEM: An Educational Model for Retention at an Urban Institution

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Abstract

This paper analyzes results of the NSF S-STEM grant "*Advancing Student Futures in Science, Technology, Engineering, and Mathematics*" awarded in 2015 to New York City College of Technology (City Tech). City Tech is a minority and Hispanic serving institution ranked third in the nation by NSF in the number of associate-level STEM degrees awarded to Black students, 23rd in degrees awarded to male students, and 48th in degrees awarded to women. During the past two years (fall 2015 - spring 2017) we have provided ninety-five scholarships. The grant program provides comprehensive support structures at critical junctures including: financial assistance; mandatory academic advisement per semester and end-of-the-semester guidance meetings; exposure to undergraduate research opportunities in various STEM fields campus wide, within, and outside City Tech; personal one-to-one need-based communication; and STEM field trips, seminars, and peer-led workshops. Through these interventions, we observe notable improvement in student retention and an increase in undergraduate research activities. Additionally, we have been able to maintain a continuous cohort. By encouraging our current and former scholars to engage in the wider professional and academic community (by opening and maintaining LinkedIn accounts, for instance) and through their participation in various research activities, we also observe student growth in establishing their professional STEM identity.

Introduction

The National Science Foundation (NSF) S-STEM program [1] provides scholarships to high achieving financially needy students in science, technology, engineering, and mathematics. The City Tech's S-STEM project "*Advancing Student Futures in Science, Technology, Engineering, and Mathematics*" supports students in five associates and baccalaureate majors (Applied Math, Computer Science, Biomedical Informatics, Chemical Technology, and Applied Chemistry). This work-in-progress project provides comprehensive support in multifaceted ways: (1) financial support through scholarship, (2) mandatory academic advisement, (3) career and graduate school exploration, (4) undergraduate research or other extra-curricular opportunities, (5) cohort-strengthening high impact social support. Particular emphases are also placed on female and underrepresented minority (URM) students' recruitment and retention in STEM fields.

We recognize the importance of identifying strategies to employ that may potentially lead to higher persistence of students, particularly of low-income students, in an urban STEM setting [2]. In thinking about how to best deploy resources, we formulated our multifaceted approach based on a number of interventions that have proven to be effective. We have combined student support programs and activities that saturate the exposure of students to the college and the curriculum, with intensive advisement as foundation. We explicitly aim all our activities to provide instances that would move students through towards graduation, a deliberate principle that has shown to have a significant effect on student persistence [3].

Foremost, financial aid and scholarship awards based on the financial need of students have been shown to positively affect retention [4, 5]. Specialized curricular advisement, occurring periodically during critical points throughout the semester, and during early registration, was

designed to ensure constant positive interaction with the student while eliminating errors in course registration (an alarmingly common occurrence in the college). Consistent and thorough advisement has been shown to be critical to student retention among many interventions [6, 7]. Undergraduate research experience has also been shown to enhance student persistence particularly for African American and Hispanic students [8], increase the possibility for graduate studies and other research activities [9], improve research skills and over-all performance in graduate school [10], and permit the channeling of students into the STEM workforce [11]. One-on-one communication, both formally in an advisement setting and informally outside the classroom, has been shown to affect student retention significantly [12]. Finally, comprehensive tutoring support, such as the Peer Led Team Learning approach, has been shown to have substantial impact on student success [7, 13].

The S-STEM scholars are selected primarily based on academic merit as well as financial need. The scholars must maintain a high GPA standard to be eligible for continued support. In addition, the scholars are expected to take advanced classes and heavier course loads with the goal to graduate early or on time. The awardees may receive up to $3,100.00 per semester. This scholarship does not replace a student's current federal student aid related to tuition or fees; rather it provides additional monetary assistance. In the first two years of grant funding, the S-STEM project was able to support 95 scholarships (total 47 students), 15 scholarships more than the 40 scholarships per year proposed originally. Our original budget was formulated based on 20 scholarships per semester with the maximum possible amount a student may receive. Although most students received the maximum amount due to their large unmet financial need, some students received lower amounts since their unmet needs are smaller. Therefore, we were able to support additional students using the surplus.

Table 1 summarizes relevant statistics of the cohorts that were supported by this grant. Among the scholars, on average, 43% are female and 46% are identified as underrepresented minority (URM). All scholars have declared as majors in BS Applied Math, AS Computer Science, BS Biomedical Informatics, AS Chemical Technology, or BS Applied Chemistry.

S-STEM Program Activities and Outcomes

	Spring 2015 (Pre-scholarship)	Fall 2015 (n = 23)	Spring 2016 (n =28)	Fall 2016 (n = 23)	Spring 2017 (n = 21)
Table 1 Total scholarships awarded during fall 2015 – spring 2017 Actual (95); Proposed (80)					
		40% URM students		52% URM students	
Males		14 (~61%)	16 (~ 57%)	12 (~ 52%)	12 (~ 57%)
Females		9 (~39%)	12 (~ 43%)	11 (~48%)	9 (~ 43%)
Mean Cumulative GPA	3.48	3.46	3.49	3.52	3.57
Median Cumulative GPA	3.45	3.43	3.5	3.48	3.581
Average	15.17	15.65	15.18	14.04	15.71

Credits Earned					
Median Credits Earned	15	16	15.5	14	15

Table 2 shows the results of a paired t-test performed on the first cohort data (n = 17) who did not graduate at least until spring 2016. The critical t-values are found to be approximately ± 1.75 for the significance level of α = 0.1 (two-tailed). The table displays the impact of our scholarships before and after the students received the scholarship. Eighteen students out of this first cohort persisted at least until spring 2016; however, one student's data was dropped, since his GPA went below 3.0, to eliminate outlier effects. Note that some scholars in the first cohort have already graduated after receiving the scholarship for one semester or may have graduated after spring 2016. Results from t-statistics do not show significant differences between the two cases, in terms of cumulative GPA and earned credits. However, as the students advance in their respective programs and take higher level courses, even maintaining their GPAs can be quite challenging. It should be noted that many scholars in the first cohort were already in advanced stages of their studies (i.e., junior year for the BS degrees) and thus require fewer courses in their last semester to graduate. Therefore, we do not observe significant differences in earned credits.

Table 2					
Comparison between Fall15 and Sp15			Comparison between Sp16 and Sp15		
Difference Cumulative GPA	Difference Semester GPA	Difference Earned Credits	Difference Cumulative GPA	Difference Semester GPA	Difference Earned Credits
Mean -0.00706	Mean -0.08665	Mean .29412	Mean -0.01053	Mean -0.13124	Mean -1
stdev 0.05902	stdev 0.3802	stdev 2.6638	stdev 0.0936	stdev 0.4709	stdev 2.5205
t-stat = -0.49313	t-stat = -0.93965	t-stat = 0.45525	t-stat = -0.46401	t-stat = -1.14899	t-stat = -1.6358

The grant program has strived to implement a coordinated effort to infiltrate many aspects of the student's college experience with effective interventions to maximize persistence. Foremost, the National Academic Advising Association (NACADA) [14] recognizes the crucial role played by academic advising in fulfilling the goals of higher education while ensuring student success. Consistent with this and other studies on advisement [6, 7], every semester, scholars are required to meet with an academic adviser from their major departments for course advisement and optimal graduation planning, as well as with an S-STEM team member for an end-of-semester one-to-one meeting to discuss their current academic status along with their graduate school or professional career goals.

Mentoring also plays a crucial role for women and minority students who are significantly under-represented in academia, particularly in STEM fields [15]. When asked about the key factors in recruiting and retaining women to careers in the trades and STEM fields, Donna Milgram [16],

the executive director of the Institute for Women in Trades Technology and Science (IWITTS) identified the paucity of female role models and female mentors in STEM careers. In line with her impressions, some of our activities have been explicitly aimed to encourage and support female students, such as holding STEM luncheons for female students and seminars featuring prominent female speakers. It may also be relevant to state here that three out of the four PIs for this grant, who have extensive formal and informal interactions with all scholars throughout the grant period, are female scientists.

Strong emphasis is placed on undergraduate research and internship experiences, known to lead to success in STEM careers [8-11]. To encourage research activity, the grant has connected students with college faculty with active research and who host undergraduates as research students, and well as with industry partners with undergraduate research programs. Many scholars have taken advantage of these opportunities, and have presented their scientific work at local, regional, and national conferences.

S-STEM scholars are required to participate in multiple activities including field trips, seminars, peer-led team learning (PLTL) workshops, and research mixers, and conferences organized by the team or by other college faculty members. These required activities have led scholars to various undergraduate research and/or internship opportunities, and have exposed them to research methodologies and hands-on project design. This type of support has also provided a sense of belonging, a critical aspect of persistence, and keeps students on the path of a seamless, efficient progress towards graduation. Scholars are also required to set up LinkedIn accounts for establishment of professional STEM identity and future follow up. By the end of the second year, 100% of our past and current awardees have opened LinkedIn accounts; the continuing scholars are strongly encouraged to update their accounts each semester. These various social bonding activities are provided in order to build a strong support system and a sense of community.

Finally, one-on-one communication via individual advisement meetings, periodic emails for announcements and deadline reminders, timely personalized email replies, and organized seminars and field trips give ample opportunity for the faculty PIs to interact with the student outside the classroom. These interactions allow faculty to address nonacademic or personal factors that might affect curricular success, an approach that has been shown to positively impact student retention [12].

As a result of these initiatives, out of 23 (9 female) first cohort students, 18 have graduated (78%), while 3 (13%) are still continuing their STEM majors, 1 (4%) left and joined another college to pursue another STEM major, and 1 (4%) lost the scholarship due to low GPA. Note that the City Tech's five year "still enrolled" and graduation rates of full-time freshmen in baccalaureate program entering in fall 2010 respectively, are 13.2% and 19.5% (4% associate degrees and 17.8% baccalaureate degrees awarded) [17]. Although, a greater percentage of all bachelor's degrees are awarded to females than to males in 2013 – 2014 (57% vs. 43%), in STEM fields, however, this number is lower for females than to males (35% vs. 65%) [18]. Therefore, in our efforts to encourage and support female students in STEM disciplines, we have been successful in retaining 100% of the first cohort female population. Among these 9 female students, 8 (89%) already graduated and 1 (11%) is still continuing her studies. Other notable

results include increased student participation and accomplishments in research activities. During our first two year period, 29 out of 47 awardees (~62%) have participated in some form of undergraduate research activities through various college wide research initiatives such as Honors Scholars, Louis Stokes Alliances for Minority Participation (LSAMP), Emerging Scholars Program, and CUNY Research Scholars Program. Many of these students have continued doing research for several semesters. Students are also selected in various grant related research activities. Some of these research projects are funded by the Mathematical Association of America (MAA) National Research Experience for Undergraduate Programs (NREUP) (Rutgers University), NSF Research Experiences for Undergraduates (REU) program, CUNY SII through Baccalaureate Student Research Program (BRSP), and Minority Science and Engineering Improvement Program (MSEIP). With the collaboration of faculty research mentors, students have been performing cutting edge research on topics including the characterization of a *Tetrahymena thermophilia* sirtuin protein; satellite and ground-based remote sensing; designing an alternative 911 mobile communication system; designing the mobile app screen for user, first responder, and operator; analyzing and assessing algorithmic running times; assessing taxonomic biodiversity by different methods; studying Alzheimer's disease; modeling tools as a proxy for weather impacts; detection and fate of low-molecular-weight compounds in post-reverse osmosis; Conway's RATS sequences; Stetson mesophotic monitoring, and other noteworthy projects.

The impact of the "*Advancing Student Futures in Science, Technology, Engineering, and Mathematics*" on students has reached beyond expectation. More than just the financial support, many students have reported personal growths and confidence in their STEM identities. In particular, the female and the underrepresented minority students have reported the greatest growths and appreciations for the opportunity. A number of success stories, as recounted by the scholars themselves, are reflected below:

The NSF S-STEM Scholarship has been an unfamiliar, yet amazing opportunity and experience last semester. I say unfamiliar because I never imagined being part of scholarship program at some point in my college life. The many workshops provided like graduate school speeches and speeches from New York City College of Technology alumni were very inspiring. These speakers provided me with an abundance of information about graduate school and in a way encouraged me to make the most out of my undergraduate studies by taking the opportunities that are offered. Mandatory meetings and advisement with an assigned professor was also beneficial. As tedious as some people may have thought it was, it definitely made me feel like I had someone looking over me and like I had guidance for future college semesters. The financial assistance was also valuable because it provided me with extra money in case of a school emergency or to spend towards a summer/winter course…. Overall, the NSF S-STEM scholarship gave me the opportunity to be part of all these beneficial workshops, trips, and gatherings. It also gave me more confidence in myself and my work ethic. I would like to thank all the professors that came together to create this amazing scholarship program and I would also like to thank the National Science Foundation for funding this program with a generous grant.

…we had an opportunity to hear from our classmates at the STEM conference. I hope that in the future, we can share our research experience in new and exciting ways. It's very hard to digest information from a variety of topics when it is lectured at me for several hours. I'm much more

able to engage in things like poster presentations and small group sharing. I loved the moment we had during the conference at the beginning of the semester in which we had a moment to get fed and speak together. Shared meals are so important to a community. Moving forward, I would love to have semi-regular student-led meet-ups with my fellow STEM scholars. We have a lot to offer each other and not enough opportunities to do so. ...Thank you so much for the scholarship and extracurricular programming. I hope to see this STEM program find its feet and grow a community of dedicated City Tech Alumn's. Our 80% transfer rate cripples the student body, and the STEM scholarship program has an opportunity to keep a group of intelligent-driven engineers together. I just hope we have more opportunities to be together as peers in addition to our valuable time as pupils.

This semester I attended the NYCWiC conference in Rochester, NY, this trip was very inspiring specially being a minority woman. I had the opportunity to hear Reshma Saujani, the founder of Girls Who Code, speak about her experience as a politician and how her defeats in politics inspired her to become an advocate to close the gender gap in technology. She inspired me to advice people and parents in changing our culture and not allowing girls to "dislike" STEM. I learned that if we teach girls at a young age about technology, the probabilities of them choosing a STEM major is very high. We should end the stigma that that is only for boys or only boys like that. And Girls Who Code is doing exactly that, exposing young girls that come from disadvantage neighborhoods to computer program and helping them discover their passion. I also had the opportunity to attend workshops and meet women who work in fields of technology. These women faced many obstacles that they were able to overcome due to their passion for what they do and to inspire more women. This trip inspired me to become one of those women.

The NSF-STEM scholarship has helped me tremendously. I have been unemployed for 2 years, in order to focus, completely, on my classes. The grant as helped for 1 year of those 2 years. I have had to depend on others financially, and the grant and the way it is distributed throughout the semester have helped me overcome many obstacles. I have used it for transportation purposes, books, and to even pay for my tuition when financial aid did not pay fully. It is also great that the money is broken down in pieces because it is not spent all at once, and it great to know I have more checks coming in. I am forever grateful for this grant, and the people who put it all together because it allowed focusing less on my financial needs and more on my classes

Growing up in a low-income household, I've known about manual labor, supply and demand, and the importance of work from a young age. The NSF S-STEM Scholarship had provided excellent guidance and support in the sense that I can allocate time and resources towards schoolwork, my career and my studies. The scholarship provides a monetary incentive that is delivered three times throughout the semester for students who have excellent grades, and who are working towards their career. Those three payments have been useful in a variety of ways. Personally, those payments were dedicated towards the recovery of one of my laptops that held a ton of research data and results. Being able to get that laptop back was only possible because of the scholarship. I didn't have any extra funds to dedicate towards that necessary expense...Not only do they provide monetary incentives, but they also offer personal support, and academic advisement. In addition to that, there were several guest speakers and presenters who spoke about their position in the workforce. They also hosted a few field trips, so that we can learn more about certain jobs, and the people who work there. These were all exciting opportunities,

and the amount of knowledge that came from each of them was immense. My favorite part of it all was the one on one conversation with ----. She provided wonderful input towards my career plans, and supported my decisions, no matter what they were. She provided great guidance and gave me ideas for future goals and steps to take. The NSF S-STEM Scholarship is an excellent program, and I would highly recommend it to any student.

Conclusion

There are numerous ways to measure success in a particular program: retention, graduation, increased GPA. One metric that we have observed is the increase in undergraduate research activity. Undergraduate research, as considered by George Kuh, is a high impact practice, which gives undergraduate students the skills needed in the workforce and supports STEM gains [19, 20]. Practices such as this and others, integrated in our NSF S-STEM program, are proving to be effective in retaining students in their respective degree majors through graduation. Students are engaged by the variety of seminars, speakers, workshops, field trips, one-to-one end of semester mentoring, and mandatory advisement – all of which play a significant role in retention. We are continuing assessment of a number of the key factors and outcomes that are associated with an NSF S-STEM program that is proving to be successful in a minority serving institution.

Acknowledgement

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