SUPPORTING UNDERGRADUATE UNDERREPRESENTED MINORITY STUDENTS FOR SUCCESS IN STEM

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This presentation reports on a model for engaging, retaining, and supporting undergraduate STEM students, and in particular women and underrepresented minorities (URM), which aims at: recruitment of students in the STEM disciplines and in particular URM students; increased persistence of students; increased graduation rates, and shortened time to graduation. The model has been tested and found to be successful at an urban northeastern university in the USA that has been designated as a Hispanic-serving institution. In this presentation, we describe this model, built from support strategies that include mandatory academic advisement; increased exposure to early research experiences; expanded one-on-one faculty mentoring of students; scholarships; robust supporting peer and mentor communities; and we present some preliminary findings.

INTRODUCTION

This presentation offers a model for engaging, retaining, and supporting undergraduate STEM students, and in particular women and underrepresented minority (URM) students. The model has been tested and found to be successful at an urban northeastern university in the USA, designated as a Hispanic-serving institution. The model integrates evidence from psychology, education research, and experience into an effective program[1] for increasing success of undergraduate URM STEM students, and aims to:

a. recruit students in STEM, and in particular URM and female students;
b. increase persistence of students;
c. increase graduation rate, and
d. shorten time to graduation.

In what follows we describe the model for supporting URM students in STEM through mandatory academic advisement each semester; increased exposure to early research experiences; expanded one-on-one faculty mentoring of students; scholarships; and robust supporting peer and mentor communities; and we present some preliminary findings.

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FACTORS CONTRIBUTING TO LOW SUCCESS OF WOMEN AND UNDER-REPRESENTED MINORITY IN STEM

Multiple factors contribute to the low success rate among URM students in STEM. Many undergo a difficult transition to college, and many of them are likely to be first-generation students (Choy et al., 2000, McCarron & Inkelas, 2006). Furthermore, many face challenges in completing introductory science and math courses due to insufficient preparation in high school (Chang et al., 2014) and find the limited interaction with professors disaffecting (Labov, 2004, Gasiewski et al., 2012). Such struggles may be further exacerbated by the perception of the academic environment as unfamiliar and alienating, particularly by women and URM students (Ong et al., 2011; Beasley and Fischer, 2012).

Successful integration depends not only on academic but also on social dimensions of the college (Tinto, 2005). Recent research has shown that STEM persistence is associated with students' ability to cultivate a robust STEM identity (Carlone & Johnson, 2007). It has been found that enculturation into STEM and STEM-related study or career is a part of a process of identity formation (Christidou, 2011). The critical role of STEM identity, related to conceptions of science (Carlone & Johnson, 2007) and mathematics identity (Boaler, William, & Zevenbergen, 2000; Martin, 2000), has been gaining attention among researchers. Recent studies relate aspects of students' self-perceptions as STEM learners and future STEM specialists to competence, performance, and recognition (Herrera et al., 2013). Thus, it has been observed that even high achieving STEM students may struggle to identify with STEM and find connections to their personal goals (Kozoll & Osborne, 2004). On top of these factors, many of these students struggle with considerable financial pressures in paying for college and taking care of their families while earning a degree.

Successful Programs and Models Increasing Success of Students in STEM

There are examples of numerous programs that have resulted in increased persistence, graduation rates, and successful transition to STEM graduate programs or careers. The PEER Led Team Learning Leadership program and the PEERS program at UCLA utilizes academic and career seminars, holistic academic counseling, research seminars, and collaborative workshops for first-year STEM students (Liou-Mark et. al. 2018, Toven-Lindsey et al., 2015). A three-tiered mentoring model was piloted by Ghosh-Dastidar & Liou-Mark (2014) and found successful with URM and female students. Other successful programs like the Meyerhoff Scholars, the Biology Scholars Program at University of California, Berkeley, Gateway Science Workshops at Northwestern University, and the LA-STEM at Louisiana University all share three common interventions widely recognized as successful program components: early research experiences, active learning, and membership in STEM learning communities (Graham, 2013). We have considered all of the above in designing a program to support undergraduate STEM students, particularly women and URM students.

A HOLISTIC MODEL FOR SUPPORTING STUDENTS IN STEM

Considering evidence from research and successfully implemented university programs, we have taken a holistic approach in designing a program to support participating undergraduate URM STEM students—hereafter referred to as STEM scholars. The program extends support with the following components: mandatory academic advisement; organized lectures, seminars, and informal meetings with STEM researchers and professionals; increased exposure to early research experiences and extended internships; formed learning communities of STEM student peers; robust one-on-one faculty mentoring, and career and peer-counseling (Diagram 1)

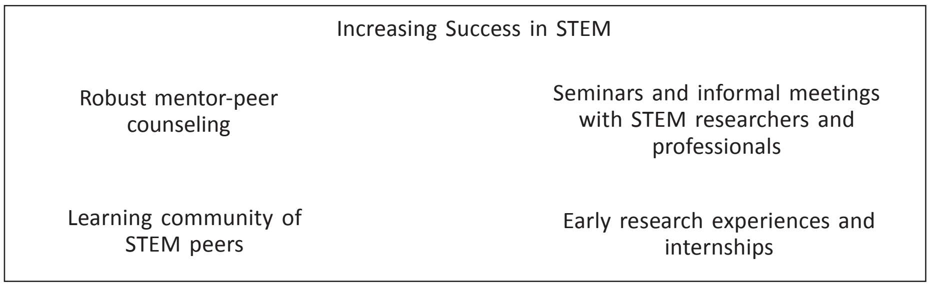

Figure 1: A model for supporting students for success in STEM

A more detailed plan for institution-wide activities in each of the four categories follows:

a) The program organized lectures, seminars, and informal meetings with STEM researchers and professionals, including women and URMs.

We periodically organized formal lectures and seminars by invited speakers, women and URM included, on various STEM topics. We also organized informal meetings with scientists and industry professionals with Q &A opportunities for the STEM scholars. We regularly invited City Tech alumni speakers holding jobs in industry or pursuing postgraduate studies in a STEM- related field. These forms of meetings between students, faculty, and invited scientists were very popular. We organized field trips to science exhibitions and tours at different off-campus locations, including the Museum of Natural History, the National Museum of Mathematics (MoMath), the Advanced Science Research Center at CUNY, the New York Genome Center, Google, the EPA, and the Federal Reserve Bank (NYC). STEM scholars overwhelmingly reported that the invited lectures were informative, and the field trips were educational.

b) The program increased exposure of STEM scholars to early research experiences and extended internships.

We utilized existing resources and organized hands-on workshops and seminars throughout the academic year for all STEM scholars in order to foster and maintain interest in STEM. One example of such activity is the Math Club, where students meet every week to discuss different math-related topics. Another example is the recently founded SIAM (Society of Industrial and Applied Mathematics) Student Chapter at the college, whose goal is to introduce and make accessible to undergraduates cutting edge research topics in applied mathematics and industry, while providing career guidance and helping STEM students connect with faculty in order to work on research projects. SIAM meets twice a month and provides the STEM scholars with a venue to share ideas that can help lead to faculty-guided research projects.

Based on a successful mentoring model (Ghosh-Dastidar & Liou-Mark, 2014), our program encourages all

STEM scholars to work on such research projects, whether through the college's Emerging Scholars Program, CUNY Research Scholars Program (CRSP), or various other undergraduate research opportunities available at the college, within the university, and at off-campus facilities. A biannual Research Mixer event organized by City Tech faculty provides students about various on-campus research and/or internship opportunities. Moreover, most of the baccalaureate programs in our institution, including Applied Mathematics, Biomedical Informatics, Applied Chemistry, and Applied Computational Physics, require completion of an extensive internship as part of their respective curricula, and we extended these internships to our STEM scholars. Many students from these baccalaureate programs have been active in presenting their research at regional and national conferences, and the STEM scholars were no exception. They were supported by various institutional structures such as the WAC (Writing Across the Curriculum) Center, which offers workshops on writing research proposals and abstracts, on proper citation and attribution, and on preparing poster presentations. The program has also worked on creating opportunities for multidisciplinary and multi-institutional research projects for teams of STEM scholars, an example of which is the joint undergraduate research collaboration between the college and the Chemical Engineering Department at Indian Institute of Technology (Kharagpur, India). Based on these concerted efforts, around 75% of the STEM scholars reported research and/or internship experiences during the program duration.

c) The program formed and fostered learning communities among STEM peers.

We organized multiple learning communities and created program-related structures to foster their success. Whenever possible we arranged for pairs of participating STEM scholars to collaborate on related research projects supervised by a faculty member. Furthermore, we had a solid academic support structure that principally relied on peer learning. Peer-led Team Learning (PLTL)—a student-centered model wherein participants actively learn in small groups facilitated by a student peer leader (Gosser et al, 2000)—is broadly utilized at our institution. A sizable portion of our mathematics classes feature PLTL supplemental workshops, which meet once a week for an hour of collaborative mathematics problem solving. Results have shown that the math courses with PLTL workshops have at least 15% higher pass rates, and at least 15% lower withdrawal rates (Liou-Mark et al, 2013). Results also showed the PLTL to be highly effective for first-year underrepresented minority STEM students (Liou-Mark et al, 2015; Liou-Mark et al, 2018). Among introductory biology students who opted not to enroll in the optional lab course, those who participated in PLTL averaged more than a letter grade higher than those who did not (Snyder et al, 2015). Other studies of the effect of PLTL have shown that non-PLTL population shows approximately 65.5% passing rate compared to approximately 81% for courses with PLTL workshops (Cracolice & Deming, 2005). In our case, many of the STEM scholars benefit from the PLTL support environment not only as participants in the peer-led groups, but also as peer leaders, who receive peer-leading training and facilitate learning in the peer-led communities.

d) The program offered a mandatory academic advising, robust one-on-one faculty mentoring, career and peer-counseling for STEM scholars.

All participating STEM scholars are required to meet with faculty mentor regularly and discuss academic progress and career development opportunities. Such mandatory one-on-one academic advisement is scheduled at least twice a year before the beginning of registration for classes for the following semester. Such advisement has been found to be particularly beneficial, as it helped student navigate the shortest path to graduation.

Additionally, we directed STEM scholars towards a wide range of career counseling and job-placement services. The Counseling Services Center offered help to students who were uncertain about their career choices. A number of online tools such as a Virtual Career Library and career assessment instruments including SIGI (a comprehensive, interactive, computer-assisted career guidance program) and the Strong Interest Inventory (an interest inventory used in career orientation) were made available to the STEM scholars as well. Regular peer gatherings offered participating STEM scholars space to discuss internship, research, application to graduate school, and other academic topics. STEM scholars were also required to open LinkedIn accounts, which has been shown to be an efficient way for alumni to stay in touch with one another and with the institution.

PRELIMINARY FINDINGS

We have the following reports available on the planned activities and outcomes:
1) The program recruited a high percentage of women and underrepresented minority students from local minority-serving high schools, as well as from undeclared and liberal arts majors with strong mathematics background who were interested in enrolling in the targeted science, technology, engineering, and mathematics majors. Table 1 shows the number of STEM scholars enrolled by semesters, percentage of women enrolled, and amount of scholarships given.

Semester	Fall 2015	Spring 2016	Fall 2016	Spring 2017	Fall 2017	Spring 2018	Fall 2018	Spring 2019
# of scholars	23	28	23	21	26	30	19	22
Amount Awarded	$54,800	$69,540	$56,153	$55,320	$55,575	$62,725	$36,350*	$51,527
% Women (all majors)	39% (9)	43% (12)	48% (11)	43% (9)	50% (13)	50% (15)	63% (12)	68% (15)
% Women (Applied Math & Computer Science majors)	25% (2/8)	23% (3/13)	33% (3/9)	30% (3/10)	38% (5/8)	23% (7/16)	54% (7/13)	54% (7/13)
% Women (Biomedical Informatics & Chemical Technology)	47% (7/15)	60% (9/15)	57% (8/14)	55% (6/11)	44% (8/18)	57% (8/14)	83% (5/6)	89% (8/9)

Table 1: Scholar Profile, Percent Women Recipients of Scholarships by Major

From 2015 to 2019, the percentage of women STEM scholars who received financial support in the form of scholarships increased by 29%—from 39% in the Fall semester of 2015 to 68% in the Spring semester of 2019 in all STEM majors; and from 25% in the Fall semester of 2015 to 54% in the Spring semester of 2019 for Applied Mathematics and Computer Science majors alone.

2) The program provided comprehensive support structures—financial support, academic advisement, academic support, and career counselling—at critical junctures.

* In Fall 2018 the students' unmet financial need decreased and thus STEM scholars were awarded a smaller amount in scholarships compared to previous semesters.

Semester	Fall 2015	Spring 2016	Fall 2016	Spring 2017	Fall 2017	Spring 2018	Fall 2018	Spring 2019
# of scholars	23	28	23	21	26	30	19	22
% Receiving Advisement	100%	96%	100%	100%	100%	100%	100%	100%

Table 2: Percent of Scholars Receiving Faculty Advisement

Nearly 100% of STEM scholars have consistently received academic advisement, and 100% of them met at least once per academic year with the program leaders for one-one-one mentoring related to academic progress, career counselling, graduate studies, and professional development.

3) The program organized lectures, seminars and informal meetings with STEM researchers and early exposure to research and internship opportunities.

There were multiple talks, informal meetings, museum visits, seminar and workshops consistently offered throughout 2015-2019. Nearly 100% of the STEM scholars attended at least one of these events per semester. About 75% of the STEM scholars were engaged in at least one research project throughout the program period, and 89% of them reported on being either a peer-leader or workshop participant. In addition, 21% of the STEM scholars have presented research posters at Women in Computing Conference. Data on other conference presentations are still pending.

4) The program facilitated forming STEM peer-communities and has made concerted efforts in strengthening them.

Over the reporting period, multiple pairs of STEM scholars were formed and organized to work on a research project with a faculty mentor. This data is still being processed.

Additionally, 90% of the STEM scholars reported to have opened a LinkedIn account in order to stay in touch with peers or follow scientists who had given presentations during the period.

5) The program retained and graduated STEM scholars at a faster rate and with higher GPA and lower total number of credits earned by graduation.

The program retained and graduated STEM scholars through strong mentorship and advisement for selection and registration for the optimal courses and number of credits. Participating STEM scholars earned on average 29-30 credits annually, which is higher than the average number of credits per semester earned by students in STEM majors. The average STEM scholars' cumulative GPA was also higher compared to the average cumulative GPA of students in STEM majors. Table 3 shows STEM scholars' mean cumulative GPA and mean number of credits earned during each semester of the program.

Semester	Fall 2015	Spring 2016	Fall 2016	Spring 2017	Fall 2017	Spring 2018	Fall 2018
Mean Cumulative GPA (Median)	3.46 (3.43)	3.53 (3.58)	3.50 (3.52)	3.52 (3.56) $\sigma = 0.31$	3.52 (3.54)	3.56 (3.55)	3.59 (3.59)
Mean Number of Credits Earned (Median)	15.65 (16)	13.86 (14)	14.04 (14)	15.71 (15)	14.19 (14)	15.00 (15)	15.42 (16)

Table 3: STEM Scholars' Cumulative GPA and Credits Earned per Semester

For comparison, full-time freshman in bachelor's programs at the same institution in AY 2014-15 earned on average 22.7 credits and only 23% of all students earned 30 or more credits. Full-time students in associate (two-year) degrees in the same institution in AY 2014-15 earned on average 19.4 credits and only 9% of all students earned 30 or more credits.

In addition, the average total number of credits earned by STEM scholars by graduation was also higher compared to the average total number of accumulated credits by graduation of students in STEM majors. Table 4 shows the average number of credits and GPA earned by STEM scholars at graduation.

Academic Year	Associate Degrees		Baccalaureate Degrees	
	Mean Number of Credits	Mean GPA	Mean Number of Credits	Mean GPA
AY 2015-16	81.5 (n=2)	3.375	124.8 (n=7)*	3.57
AY 2016-17	58 (n=1)	3.98	133.6 (n=15)*	3.46
AY 2017-18	80 (n=1)	3.17	125.5 (n=10)	3.61
AY 2018-19 (Fall only)	71 (n=1)	3.39	121 (n=4)*	3.71

Table 4: GPA and Credits Earned by Graduation

Overall, the STEM scholars from associate degree (two-year) programs earned on average 74 credits by graduation as compared to an average between 80 to 84 credits earned by an associate degree graduate with a STEM major. Similarly, the STEM scholars who graduated with baccalaureate degree earned on average 128 credits by graduation as compared to an average between 103 to 138 credits earned by a baccalaureate degree graduate with STEM major.

Eighty percent (80%) of the STEM scholars have either graduated or will be making satisfactory progress toward graduation by AY2019-20. As of Fall 2018, five students have earned associate degrees and 36 earned bachelor's degrees. This accounts for over 50% of the participants in the program who have graduated, 12 of whom with honors. On average, the STEM scholars are on track to graduate one semester earlier compared to other full-time students from the same majors who did not participate in the program. Overall, the STEM scholars who completed their degrees graduated with a decreased number of semesters of coursework.

6) The program has increased the number of STEM students transferring from a two-year program to a four-year program.

* Some scholars did not receive scholarships during their last semesters due to holding a part-time status

A total of 16 of the 82 participating STEM scholars have transferred from a two-year to a four-year degree in the five-year period. The total number of STEM scholars transfer students represents 20% of all STEM scholars, and an increase of the initial 11% of participating STEM students from a two-year degree in 2015. In summary, the program was successful in increasing student participation in STEM programs, especially women and underrepresented minority students; in increasing the number of STEM students transferring from a two-year program to a four-year degree programs; in providing comprehensive support structures such as financial support, academic advisement, academic support, and career counselling; in retaining and graduating women and underrepresented minority students in STEM; and in decreasing the number of years to graduation of STEM students who participated in the program.

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