Reflections on Experiences of a Successful STEM Scholarship Program for Underrepresented Groups

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Reflections on Experiences of a Successful STEM Scholarship Program for Underrepresented Groups[1]

Abstract

The President's Council of Advisors on Science and Technology report in 2010 stated that there is a large interest in the achievement gap among underrepresented groups, especially women, in STEM fields. To alleviate these shortcomings, the National Science Foundation has been leading the efforts to increase the enrollment of minorities in these fields and reduce these gaps. Other federal agencies have also joined the efforts, since the National Academy of Science in 2007 warned that the eroding scientific base of the nation puts the United States at a disadvantage with regards to other nations. This paper deals with reflections on how to successfully implement a university STEM scholarship program to attain the simultaneous goals of increasing STEM enrollment and increasing diversity in the STEM fields. In particular, this paper highlights the necessity of strong and broad-based (peers, faculty, and industrial) mentors. Initial results are encouraging with regards to STEM scholarship student retention.

1 Introduction

The Executive Summary of "Rising Above the Gathering Storm: Energizing and Employing America for A Brighter Economic Future," notes that "*scientific and technological building blocks critical to our economic leadership are eroding at a time when many other nations are gathering strength*"[1]. This, however, is not the first report that has spelled out the potential technological decline of the nation. In order to prevent this decline, the Executive Summary offered four recommendations "*that focus on the human, financial, and knowledge capital necessary for US prosperity. The four recommendations focus on actions in K–12 education (10,000 Teachers, 10 Million Minds), research (Sowing the Seeds), higher education (Best and Brightest), and economic policy (Incentives for Innovation)"* [1].

In addition, the 2010 report of the President's Council of Advisors on Science and Technology[2] stated that *"there is a large interest and achievement gap among some groups in Science, Technology, Engineering, and Mathematics (STEM), and African Americans, Hispanics, Native Americans, and women are seriously underrepresented in many STEM fields."* The trouble signs also come from the school system themselves. In the same Presidential report, it is stated that *"Schools often lack teachers who know how to teach science and mathematics effectively, and who know and love their subject well enough to inspire their students*." Other federal agencies, in particular, the Department of the Navy (DoN), have further recognized the status of STEM education and are concerned with the small number of U.S. citizens who graduate with STEM degrees. For example, the DoN reported that only 15% of bachelor's degrees earned by U.S. citizens are in STEM fields. Further complicating this issue is the low level of interest of American students in science[3], in comparison with other countries, particularly China and India.

1 The authors thank the National Science Foundation for supporting the STEM program at Penn State Harrisburg under grant Award ID: 1154516.

There are also several concerns with the cost of education. For example, private universities, at the high end, can run close to $50,000 per year, while public universities cost on average $19,000[4]. These factors are also a detriment to students wishing to acquire a STEM-related education.

Recognizing these problems, some science and engineering faculty at Penn State Harrisburg wrote a proposal to NSF in order to ameliorate the effects of the problems discussed. In 2012, Penn State Harrisburg was finally awarded an NSF grant tailored to increase and retain under-represented, female, first-generation, and low-income STEM students, due to demonstrated national and regional needs to augment these populations in higher education STEM programs. In order to increase the awareness of STEM fields, a new initiative, the creation of Engineering, Math, and Science Clubs at High School and Middle Schools, is being pursued. To attract the targeted students, scholarships were created, and new services and processes are being implemented, such as improved early progress reports, mentoring by role model faculty members and working professionals in STEM fields, and peer mentoring through the new STEM scholarship club. Our activities are being accomplished through a synergetic collaboration of expert staff from the Office of Multicultural Recruitment, Academic Affairs, Student Services, the Outreach Office, and the Commission for Women at our university and seasoned role model faculty members. The project team has extensive experience working with female and minority undergraduate students. Rigorous evaluations were built into the management plan to assess targeted enrollment goals, retention rates, and the impact of mentor/mentee activities, taking into account the unique characteristics of the targeted groups. This proposal was further strengthened by leveraging the resources of the Office of Development at Penn State Harrisburg to sustain this effort over time. This paper deals with reflections on how to successfully implement a university STEM scholarship program to attain the simultaneous goals of increasing STEM enrollment and increase diversity in the STEM fields as other universities have done[5].

This paper is organized as follows: In Section 2, we present the NSF STEM program goals, including recruitment and retention. In Section 3, the support services for the new scholars are explained. Section 4 describes our customized mentoring program for our STEM scholars. Initial results and comments, as well as further activities and conclusions, are given in Section 5.

2 Program Goals

The NSF-STEM program goals are in line with the mission of the School of Science, Engineering, and Technology (SSET) at our university; that mission is to increase the pool of qualified STEM candidates from underrepresented groups (female and minorities). In particular, the program goals are designed to:

- Provide renewable scholarships to STEM students
- Enhance recruitment and retention of academically talented and financially needy students in STEM fields to graduation within four years
- Support scholarship recipients by augmenting our university's student services with programs including peer recruiting and industry mentoring
- Increase the number of STEM graduates entering the workforce

In order to better understand the context of the paper, the authors offer baseline enrollments shown in Tables 1 and 2. These enrollments were taken at the time of the NSF proposal submission. It can be seen from both tables that the minority and female enrollments, especially in engineering fields, are below national averages.

Table 1: 2010 Undergraduate Minority Enrollment in SSET at Penn State Harrisburg

Ethnicity in SSET*	**American Indian**	**African American**	**Asian American**	**Hispanic American**
# Enrolled	1	20	42	14
% Enrolled*	0.19%	3.89%	8.17%	2.72%
National Average**	0.52%	5.31%	10.65%	9.58%

*Registrar's Office, Penn State Harrisburg, **Profiles of Engineering, 2010 ASEE Publication[6].

Table 2. 2010 Female Enrollment in SSET Undergraduate programs at Penn State Harrisburg

Academic Program		**SSET Enrollment***	**SSET %***	**National Average**
Electrical Eng.		4	6.2%	12.1%**
Elec. Eng. Tech.		5	7.7%	9.6%***
Math Science		5	7.7%	44.1%+
Environmental Eng.		9	13.8%	43.1%***
SDCET		10	15.4%	9.6 % ***
Computer Science		5	7.7%	10.2%***
Mechanical Eng. Tech.		3	4.6%	9.6 %***
Science (Life)		11	16.9%	60.0%[4]

*Registrar's Office at Penn State Harrisburg, **Profiles of Engineering, 2010 ASEE Publication[6]. ***This is the average enrollment for female students in all of the Eng. Technology programs. ***Degrees awarded ASEE[6]. +See[7].

2.1 Process and Its Evolution

In order to accomplish the above goals, several tasks were outlined in the proposal, which included recruitment, selection, retention, mentoring, marketing, and evaluation.

Recruitment and Selection

The recruitment strategy was based on the proposal plan, that is tapping traditional and non-traditional sources. Targeted recruitment from traditional sources included high school visits, working with the Office of Multicultural Recruitment and Admissions, and actively interacting in the Annual School Counselor's Luncheon sponsored by our university admissions office. The non-traditional sources included reaching out to minority clubs and fraternities, minority alumni, and minority mailing lists.

The next step in this implementation was to form a selection committee to choose the deserving NSF STEM scholars. The committee included representatives from the offices of Multicultural Recruitment and Admissions, and representatives from the different STEM programs at Penn State Harrisburg: Life Sciences, Mechanical Engineering, Electrical Engineering, Civil/Environmental Engineering, and Mathematics/Computer Science. The first task was to

develop rubrics for choosing the STEM scholars.

Rubrics

In order to comply with the NSF grant, the selection committee placed a numerical value on the qualifications of each potential student's scholarship application. The criteria that was developed, in order to mathematically rank each student, was the following:

- **Admission Index or GPA**
  Applicants must have achieved a minimum admission index of 2.40 (or 3.0/4.0 GPA). Note that this index may change according to the admission cycle. The effect of the admission index on the application is determined by the following formula:

  [Admission index (or GPA) – 2.40 (or 3.00)] x 10 = points added to applicant's total

- **Communication Skills: The Personal Biographical Essay**
  Each applicant is asked to write a "personal biographical essay" of no more than 300 words. This is, as much as anything else, a test of communication skills. The essay includes such components as how and why the applicant got interested in his/her chosen field of study, as well as the applicant's plans for the future. The numerical range for this criterion was from zero to a maximum of five.

- **Extracurricular Activity**
  Membership and activity in a professional or student organization (e.g., the Student Council) was given one point. An additional one point was given if the student held an officer position in a student organization.

- **Demonstrated Promise for Future Contributions to the Field**
  Applicants who demonstrated their future promise through their extracurricular activities and through their post-graduation plans (as gleaned from the personal biographical essay) were also given points. "Promise" was graded on a holistic basis such as:
    - Attending technical talks
    - Participating in Research Undergraduate Experience research at Penn State Harrisburg or any other university
    - Summer technical camps

  Demonstrated promise was given a numerical value from zero to a maximum of five.

Reference Letters

The selection committee also judged two reference letters using the range very strong (five points) to no letter (zero points). The average number of points for the two reference letters was used.

Application Process

Once the application rubrics were developed, the selection committee developed the application form. This application form included the NSF citizenship and residency requirements and was developed according to proposal guidelines. Another task of the committee was to develop a

website and brochure. The selection committee decided all applications would be on-line, with an option for standard paper application.

2.2 Recruitment Results

Number of Applications (received/accepted)

The total number of students that applied and the number of applicants that were accepted respectively for the three cycles is shown in Figure 1. The NSF STEM program at Penn State Harrisburg has been fundamental in attracting deserving students. As a consequence of having a prestigious NSF STEM scholarship outreach program, our university's Director of Admissions reported an increase of 25% for engineering applications and 87% for science applications since the inception of the NSF STEM program at Penn State Harrisburg.

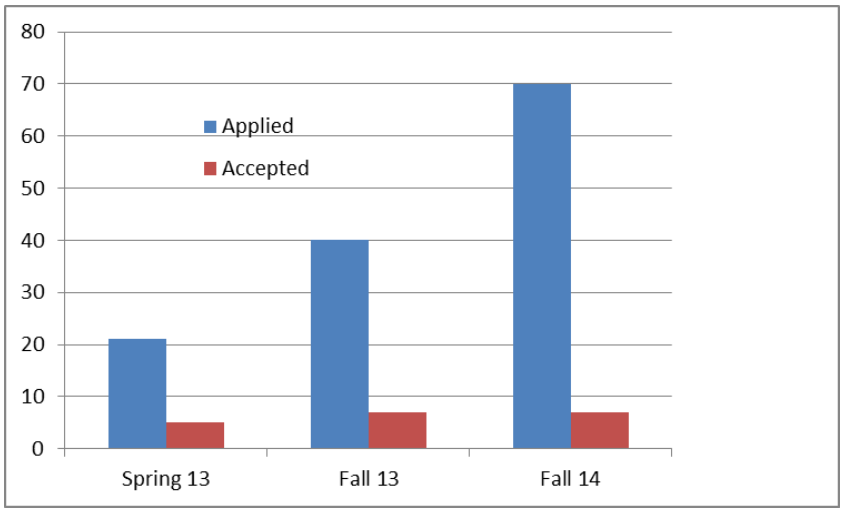

Figure 1: Number of Students Applicants and Accepted Students from Spring 2013 to Fall 2014.

Demographics (diversity, gender, major, etc.)

The gender of the students who applied is depicted in Figure 2, while Figure 3 displays the ethnic composition of the students for the same application cycle. The reader can note the significant applications spike in the third cycle as students became more aware of the NSF STEM program at Penn State Harrisburg.

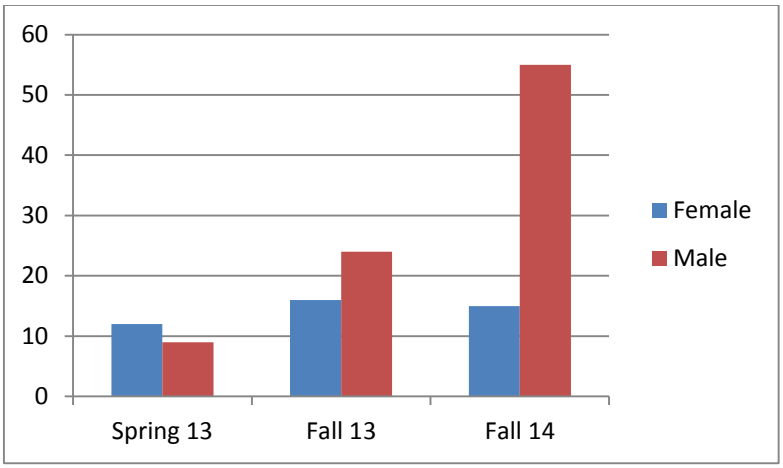

Figure 2: Gender of Applicants from Spring 2013 to Fall 2014.

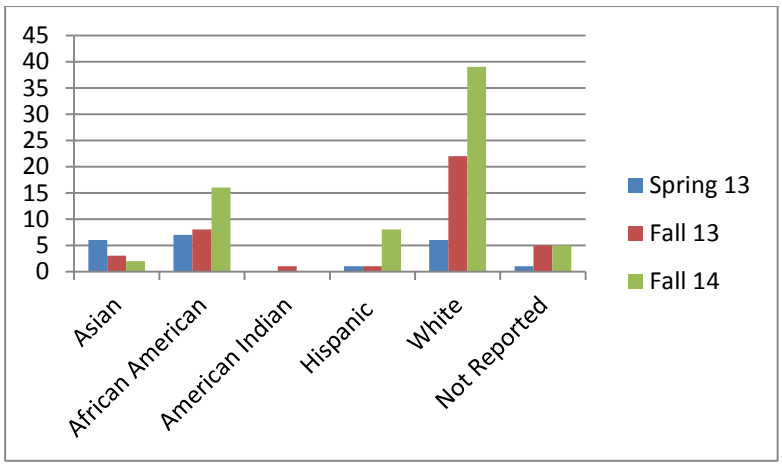

Figure 3: Ethnic Composition of Applicants from Spring 2013 to Fall 2014.

3 Support Services

In order for STEM scholars to succeed, grant funds are supporting new student activities using the Learning Center at Penn State Harrisburg to offer targeted academic support services. Because the transition from high school to college brings with it different problems, our goal for the first year scholars was focused on helping them make that transition less challenging. To that end the Director of the Learning Center and her staff, in conjunction with the PIs, developed a program to assist the STEM scholars by setting up a series of special academic skills workshops, meeting individually with specific students to customize the academic support, and by providing tutoring and academic coaching. The workshops helped the students in developing good study habits, identifying resources on campus, and dealing with other transitional issues. While these workshops were aimed at students having transitional and study issues, all were welcome to attend. These services were specifically targeted to students in the lower range of the GPA required to maintain the scholarship (from 3.00 to 3.50). The following workshops were offered:

- Time Management
- Test Taking Strategies

- Test Preparation
- Academic Reading and Comprehension

Table 3 shows the results of the attendance at the tutoring and academic skills workshops, along with information about the scholars' GPAs. It is clear from the data that the students with high and steady GPAs did not feel it necessary to utilize the resources to the same extent that those struggling more with transition and academics did.

4 Customized STEM Mentoring Program

STEM scholars need caring role models who can create a positive impact on their personal and professional development. These role models are found in mentors. Mentoring has been identified as a powerful factor [8-10] in the success of many students, in particular women[11,12], underrepresented minorities[13], and first year students [14-17]. Therefore, the mentoring program is integral to the success of each scholar.

Table 3: Results of Workshop Attendance (Fall 2013 Cohort)

Cumulative Scholars' GPA (after Fall 13)	Tutoring Appointments Fall 2013	Academic Skills Workshops	Tutoring Appointments Spring 2014
Greater than 3.5) and steady	0	0	1
Greater than 3.5)and steady	2	0	0
Greater than 3.5)and steady	1	0	0
Just above 3.0, upward trend	4	4	0
Near 2.0, declining trend	0	4	3
Near 2.0, declining trend	7	2	1
Just above 3.0	5	0	3
Greater than 3.5)	0	0	0
Below 3.0, declining trend	37	0	0
Greater than 3.5)	3	0	0
Greater than 3.5)	1	0	1
Below 3.0, declining trend	0	4	0

Mentoring forms the foundation of the program. Studies have shown that undergraduate students who are mentored tend to have higher GPAs, higher retention rates, and more credits completed per semester as compared to their un-mentored colleagues[18]. Our STEM customized, three-tiered mentoring program consists of peer mentoring, faculty mentoring, and industry mentoring. Each part has a different focus, but they all work together to support the scholar. Each of the three components is explained below.

4.1 Peer Mentoring

Peer mentoring is not new; many universities, such as Western Michigan, Texas, Montana State, and Iowa State, have successfully incorporated STEM peer mentoring. Peer mentoring is a developmental relationship that is premised on a multiple mentor approach in which benefit can be gained from a variety of experiences and people throughout a student's career. This can serve

to widen a student's learning context within and outside of the University[19]. The Penn State Harrisburg NSF STEM Scholarship Peer Mentoring Program is designed to assist and support freshman STEM students transitioning to the first year of college. The goal of the program is to help scholars develop academically, socially, and personally. Peer mentoring is a collaborative effort between upper class STEM students and first year STEM scholars. This collaboration demonstrates and models a successful college transition, and guides first year students through unfamiliar territory such as academic policies and requirements and new social activities. It has also demonstrated a positive and supportive environment in which learning process can flourish.

Through this program, STEM peer mentors can help their mentees acquire the necessary knowledge, information, and skills to succeed in college. Peer mentors also introduce mentees to new people, places, interests, and ideas. Along with suggesting new sources of information, peer mentors also encourage new students to approach other people as resources. They act as coaches and facilitators to help scholars navigate the Penn State Harrisburg system. These activities help first year students transition smoothly into university life.

Peer mentors are undergraduate students who have demonstrated academic and personal success during the first two years of their respective programs. These students are nominated by faculty members and receive very specific training on how to become peer mentors. Scholars are required to work with a peer mentor the first year; peer mentors are optional for subsequent years.

Despite the positive outcomes resulting from the peer mentoring program, there are also many challenges. Some common challenges for peer mentors include the following:

- Motivating and encouraging mentees to be excited about being at Penn State Harrisburg
- Dealing with apathy toward certain courses
- Being viewed as a parent or teacher instead of a peer
- Having mentees mistake mentors for tutors
- Not being seen as authority figures
- Planning meetings and getting mentees to show up for appointments
- Having consistent contact
- Reaching out to those who need help but won't or can't ask for it
- Troubleshooting academic and personal issues before they become serious problems

Furthermore, there were challenges in implementing the peer mentoring program itself. Some of these challenges included finding and training peers, scheduling, and the lack of a dedicated space for mentoring. In addition to solving scheduling problems, this dedicated space might alleviate some of the peer mentors challenges listed above.

4.2 Faculty Mentoring

The second component to our three-pronged mentoring program is faculty mentoring. While faculty mentoring is important for all scholars, it is particularly successful for first year students[20]. Therefore, faculty mentors are assigned to all incoming scholars, and typically remain for the duration of the student's studies at Penn State Harrisburg. STEM students are matched with faculty on the basis of shared academic interests. Thus, students who specify a

major on their application are assigned to a mentor whose specialty is in the same or a related field. Undeclared majors in science and engineering are assigned to mentors who agree to work with such students. When possible, gender and ethnicity are also accommodated.

The primary goal for faculty mentors is to help scholars identify with specific disciplines and walk a successful path through their studies. To accomplish this, mentors take a proactive role in maintaining contact with their mentees. While mentors and students are advised to meet once a month, many meet once per week throughout the academic year. Communication via e-mail or phone is also recommended for updates or quick questions. Faculty mentors encourage scholars to make effective use of their time by sharing techniques that have been personally helpful for them. Faculty mentors are also advocates for their mentees and help them network with other students and faculty, as well as assist in the scholars becoming part of the Penn State Harrisburg community. All faculty mentors are required to assess their mentees' performance and progress, and provide constructive feedback as well as positive reinforcement on a regular basis. Mentors are asked to maintain both a log of their contacts, including date, duration, and general content of their meetings, and a journal of approaches and ideas that have either helped or not helped their mentee. These logs provide documentation that contacts between the student and the mentor have actually occurred and guide the mentor in future sessions.

In addition to private meetings, the faculty mentoring program offers a number of activities and professional meetings to create opportunities for mentors and students to spend time together and/or ask questions. During the academic year there are typically eight professional meetings (four each semester) in which all the mentors (faculty and students) meet to go over an agenda (e.g., meeting minutes, STEM Student Club announcements, and mentoring information) and invite guest speakers. The guest speakers at these meetings are employees in the industry that are working in science or engineering related jobs who also fit the underrepresented STEM demographics. They present their experiences, achievements, how they got to where they are, and information about their current jobs. These meetings provide an opportunity for all mentors and mentees to gain information from each guest speaker, ask questions, and remain up-to-date with the STEM activities and social events.

Goals for faculty mentors include the following:

- Assisting mentees in developing and completing an educational action plan that includes structured preparation and participation in professional and/or scientific society meetings
- Sharing their expertise, experiences, and wisdom
- Helping mentees discover STEM-related interests and define and attain their goals
- Providing valuable opportunities by facilitating academic, career, and personal contacts
- Stimulating curiosity and building confidence by presenting new ideas, opportunities, and challenges
- Encouraging growth and achievement by providing an open and supportive environment
- Becoming role models by sharing stories of achievement with students
- Assisting scholars in participating/presenting at conferences, symposiums, and meetings, either on-campus or off campus

The faculty mentoring program was originally set up on a one-on-one basis. One of the challenges that the faculty mentoring program has faced is finding faculty with the time

necessary to devote to the STEM scholars. Therefore, network mentoring, in which multiple students are mentored by one faculty member, is being used. A recent study[21] indicates that network mentoring compares favorably to one-on-one mentoring; therefore, this was not considered a serious issue.

Assessment of faculty mentors includes:

- Monitoring the number and type of meetings
- Surveying both students and mentors regarding successful approaches
- Checking to see that scholars have taken advantage of campus and other resources related to their majors
- Verifying that scholars are aware of various campus offices, including the learning center, career support, etc.

This faculty mentoring goes beyond the simple advising given to most students in that it is customized and personalized for each scholar, in addition to being monitored closely, with mentors being much more proactive in engaging their mentees in discussions and joint interactive learning. Faculty mentors are trusted partners and guides that facilitate student growth and development, and take a special interest in their mentees.

4.3 Industry Mentoring

The last component of the mentoring program is industry mentoring. Industry mentoring provides students with guidance, counsel, and networking opportunities. It is an essential and intentional component of the NSF STEM Scholarship Program. The objective of Penn State Harrisburg's Industry Mentoring Program is to create a mutually beneficial connection between industry mentors and current STEM students at Penn State Harrisburg. Mentoring is well recognized as a strategy for personal and career development in which the mentor helps facilitate the development of the mentee by providing learning opportunities that will enhance knowledge, skills, wisdom, and confidence.

The main goal for our industry mentoring program is to educate scholars about STEM career opportunities available to them in the private and public sector and provide them with a role model in the field. The mentor inspires students to think about the range of work options available and to actively support career exploration, professional development, and networking in their field. Students are encouraged to discuss a wide range of topics with their mentors, including work in classes and how it relates to industry, career goals, and extracurricular activities.

The industry mentoring part of the program connects each student with an industry mentor and gives them a chance to interact on a one-on-one basis. Industry mentors are assigned to juniors and seniors. Faculty from each program work together to find mentors best suited for each student, based on the mentor's expertise and the student's major field of study and career goals. A mentor's commitment is for one academic year; however, the pairing may continue if both parties are interested. Industry mentors meet with their mentees at least once per month. Typical monthly activities include such things as job shadowing, inviting students to meetings or other professional events, mock interviews, career fairs, field trips, discussions about careers (the

mentor's personal story, career opportunities, how to interview, etc.), and professional development (what associations should the mentee join, what journals are best to read, etc.).

Assessment of industry mentoring is based on successful matching, a review of the various activities, support, and closure.

The goals of the industry mentor are as follows:

- Educating mentees about STEM career opportunities available to them in the private and public sector
- Providing an opportunity for students to develop a mentoring relationship and receive professional development advice from the industry
- Providing students with positive role models in the science and engineering industries
- Developing a student's commitment to actively participate in mentoring throughout his/her career, both as a protégé and mentor

The benefits of having industry mentors is that the student mentee gains knowledge about jobs and career paths and develops relationships with the industry, thus expanding their network of professional contacts.

5 Summary and Conclusions

As a consequence of having the NSF STEM scholarship program, our university's Director of Admissions reported an increase of 25% of engineering applications and 87% in science since the inception of the NSF STEM scholarship at Penn State Harrisburg. One the first benefits of this scholarship is to alleviate the financial burden for deserving female and underrepresented students who wish to pursue a STEM field. This is evidenced in several student testimonials. One stated "I am grateful for being selected a recipient of the NSF-STEM Scholarship. The financial assistance will certainly help me shift my time and energy from worrying about student loans to rather achieving my career goals of earning my Master degree in a Physician's Assistant program." Another expressed "This scholarship has helped me and my family financially. My parents don't have to stress about paying for my tuition bills. I do not have to worry about taking out private loans with high interest. It helps me focus more in school." Lastly, another stated "This scholarship will help me financially. In addition, it will assist in achieving my career goals."

The customized support services designed and implemented for this NSF STEM scholarship program have immensely helped the scholars to achieve success. For instance, one STEM scholar expressed: "Words can't describe how much I appreciate the scholarship, not only for the benefits it provides, but as a confirmation of the love for science that I have." Another STEM scholar stated "Last semester, I used the tutoring services and spoke to my mentor in a numerous occasions. The services that the program has provided for me really helped last semester as I made my way through my freshman year." In another journal, an NSF STEM Scholar wrote " how I am incredibly lucky I am to be part of programs, such as the STEM program, to motivate me to strive academically."

Although scholars have not yet completed their programs of study, some are already exhibiting success by being on the dean's list, being accepted into graduate programs, participating in research experiences at the undergraduate level, and being nominated for science awards. For instance, one student has been nominated for the PennACE JoAnne Day Student of the Year Intern award. With this award, PennACE recognizes the achievements and contributions made by undergraduate students, enrolled at member institutions, who have completed an internship or co-op assignment. One of our scholars was unsure whether or not he would be able to afford to continue attending Penn State Harrisburg to get his bachelor's degree. He was recently awarded an NSF STEM scholarship and has been accepted into a highly selective integrated undergraduate/graduate program, which only admits the top 2% of students in the major.

Although the STEM program at Penn State Harrisburg has been successful in having a diverse set of applicants, there is still a need to increase the diversity in the applicant pool by making some small changes in the marketing and selection process. Cohort integration has been a critical component in the success of the STEM scholars. We plan to continue exploring methods to encourage more. While assessment of the mentoring program is ongoing, we have not yet gathered enough data to be statistically significant. While research based on STEM mentoring is rather limited, particularly for faculty and industry mentoring, once our assessment is complete, we plan to add our results to the STEM mentoring research base.

In summary, the findings so far shows that mentoring plays a critical role in helping STEM students successfully complete their undergraduate studies and prepares them for graduate study and/or entrance into the STEM workforce. Having a well-designed mentoring program at Penn State Harrisburg, students appreciate and understand science, mathematics, and engineering more completely, gain skills and confidence, and often achieve improved academic work and performance. Future work should focus on testing the impact on students of various mentoring activities provided, such as meetings, participating in off-campus experiences, and also activities on campus.

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