The Role of Customized Mentoring in a Successful STEM Scholarship Program for Underrepresented Groups

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The Role of Customized Mentoring in a Successful STEM Scholarship Program for Underrepresented Groups[1]

Abstract

In 2011, STEM faculty members at Penn State Harrisburg applied and were awarded an NSF grant in order to increase the number and retain underrepresented, female, first-generation, and low-income STEM college students, due to demonstrated national and regional needs to augment these populations in higher education STEM programs. In a recent ASEE paper, the authors published the steps taken to implement a university STEM scholarship program to attain the simultaneous goals of increasing STEM enrollment and increase diversity in the STEM fields. In particular, the authors evaluated the necessity of strong and broad-based (peer, faculty, and industry) mentoring. Initial results were encouraging with regards to STEM scholarship student retention.

Based on this initial work, the authors paired each first-year STEM scholar with a peer mentor in the same or a similar major, in addition to pairing every STEM scholar with a faculty mentor. After conducting a mentor/mentee training session, the peer mentoring teams met on a monthly basis throughout the semester. The authors evaluated the effectiveness of the mentoring programs through a series of pre-, mid-, and post-year assessments. The authors used a combination of assessment tools from the NSF-approved Assessing Women and Men in Engineering and the Motivated Strategies for Learning Questionnaire. These tools are designed to identify longitudinal changes in the self-efficacy of undergraduate students studying engineering. Results obtained indicate a significant improvement in metacognitive strategies, goal orientation, resource management, and academic performance. Additionally, many STEM scholars expressed interest in participating in future mentoring programs. The success of the mentoring program, coupled with Learning Center initiatives and support from the NSF STEM club, enhances the STEM experience of women and underrepresented population at Penn State Harrisburg.

1. Introduction

Penn State University at Harrisburg (PSH) is an undergraduate/graduate university that enrolls approximately 5000 students, made up of 10% Asian, 12% Black/African-American, 7% Hispanic/Latino/Latina, 66% White, 3% Multi-race, and 2% other, with approximately 40% women and 60% men. STEM faculty member at this university received an NSF grant to aid in increasing both enrollment and retention of underrepresented, female, first-generation, and low-income STEM college students. In a prior paper, the authors stressed the importance of support services for STEM scholars, including tutoring and mentoring. The three mentoring components identified in that paper were as follows: peer, faculty, and industrial mentoring[1]. The importance of mentoring on the success of students has been long recognized in the literature[2-15]. Hence, the PSH NSF STEM Scholarship Peer Mentoring Program was implemented in order to help freshman STEM students transitioning to the first year of college. Peer mentors act as coaches and facilitators to help scholars navigate the Penn State University system, including the introduction of the environment, people, and new ideas[1]. Peer mentors, chosen from upper classmen, were close enough in age to the mentees to allow easier communication between

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mentees and mentors. In addition, the authors note that the NSF STEM club, one of the key components of our NSF grant proposal, allows for deep peer networking among all NSF STEM scholars and puts them at ease in immersing themselves in college life. To assess the impact of peer mentoring on the NSF STEM scholars, the authors used a combination of several tools[16,17] specifically developed to measure learning strategies and academic motivation. Results of these assessments, as well as activities on peer mentoring, are presented in Section 6.

As explained in[1], "*the primary goal for faculty mentors is to help scholars identify with specific disciplines and walk a successful path through their studies*." Faculty mentors have periodic meetings with their mentees through various means, including electronic communication. The objectives of these meeting are to support, provide positive feedback, and encourage mentees to succeed academically. Faculty mentors were advised to keep logs of the interaction with their mentees. Most of the faculty mentors were also involved in some activities with the NSF STEM club to build rapport. The effectiveness of faculty mentoring on NSF TSEM scholars was expressed through testimonials that the NSF STEM scholars wrote in their yearly required journals. These testimonials are anonymous to faculty mentors.

Industry mentoring is the last component of our mentoring plan. The objective of the PSH's Industry Mentoring Program is to create a mutually beneficial connection between industry mentors and current STEM students at PSH[1], especially with students near graduation. Typically, industry mentors present mentees with a range of options in terms of networking, job opportunities, and professional development. Most the industry mentors were invited to NSF STEM meeting sessions, where they gave short presentations, followed by engaging students through a dialogue and networking opportunities. The benefits of this type of mentoring were also expressed through scholars' journals.

Finally, one of the other big components, that complement the mentoring plan, is the support services provided by the Learning Center of PSH. In Section 5, results of the NSF STEM scholar's interactions with tutors at the Learning Center are also presented. In Section 7, the authors present a summary and conclusions.

2. The Impact of Peer Mentoring

It is well known that peer mentoring has been a very successful way to help students transition into college[2-15]. Peer mentors at PSH are nominated by program chairs and other faculty. To become a peer mentor, these students must go through peer training, typically in the form of workshops over the summer.

For the first year, because the students in our Learning Center were already trained, we opted to utilize those students as peer mentors for our STEM scholars. This past year, a new approach was taken: we paired 14 freshman NSF STEM scholars with a peer mentor in the same or a similar major. Using a peer mentoring handbook, developed specifically for this grant, we conducted a 1.5 hour mentor/mentee training session, followed by introductions of the peer mentoring pairs. After the initial training, the peer mentoring teams met on a monthly basis independent of faculty involvement.

In order to enhance cohesiveness among mentee-mentor, we encouraged them to jointly participate in the NSF STEM club activities. These get-togethers proved beneficial for everybody involved in the mentor-mentee program, as is supported by results of the surveys depicted in Section 6. Some of the NSF STEM club activities are detailed below:

1. February 24th- 2016, Capital Area Science and Engineering Fair Volunteering
2. February 26th-2016, Capital Area Science and Engineering - Award Ceremony
3. March 9th-2016, STEM Career Launch Volunteering
4. March 24th-2016, NSF STEM club talk on storm water runoff and pollutants in water supplies.

In addition to the above events, the NSF-STEM club officers participated in Central Pennsylvania food bank as a community service and organized a fund raising event at April 28, 2016, where newer members (mentees) and older club members (mentors) participated. Below, in Figure, 1 is the flyer that they used.

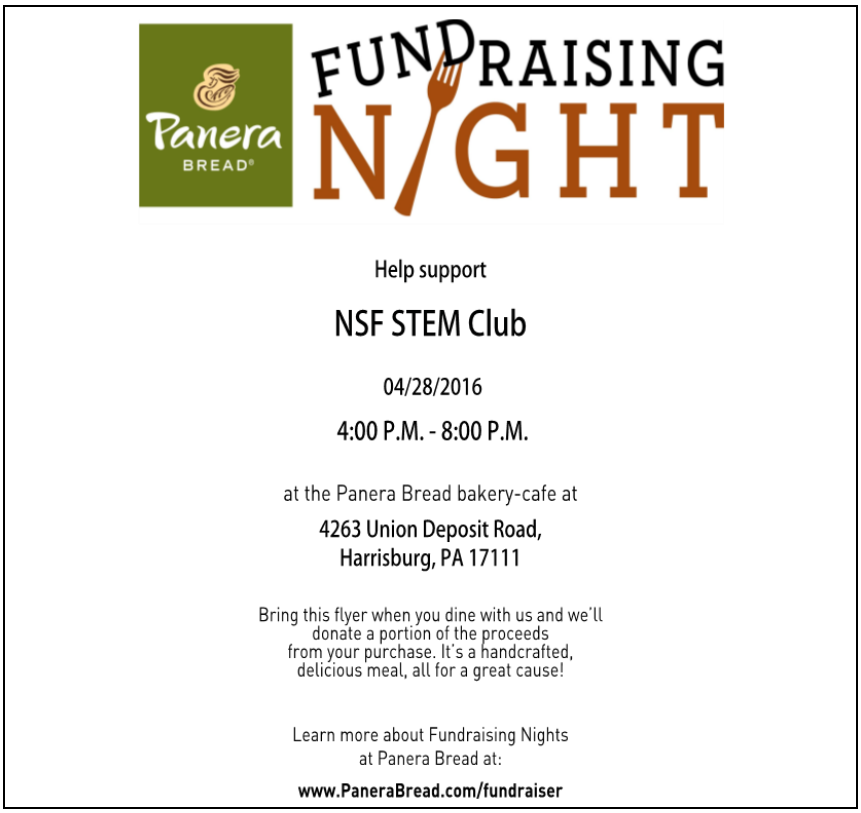

Fig 1: Flyer used in one of the NSF STEM club fundraising activities

The impact of the NSF STEM club peer-mentoring activities is demonstrated in the journal testimonials as well as the result of the mentoring evaluations (see Section 6). With regards to the testimonials, one NSF STEM scholar wrote*: "Being an NSF STEM Scholar is something I am proud of, the club has helped me in many ways my first semester of college. My first semester was pretty rough for me, my biggest problem was adjusting to online work and quizzes, missing a deadline on an online quiz tanked one of my grades this semester but I was lucky to find somebody in the STEM club who has taken the class and helped me with the remainder of the material and I was able to finish the class with a B+."* Another stated *"While the financial aid I have received for being a STEM scholar is vital to me attending Penn State Harrisburg, the opportunities that comes with being in this program is invaluable. The STEM club has been very*

important to my success at Penn State University. I have met several students in this program that I also share classes with. Being involved in this program has only propelled my interest in STEM and computer science." One more wrote *"The STEM scholarship club has provided me with countless opportunities to further enhance my education experience at Penn State Harrisburg that would be impossible to receive elsewhere. From field trips and guest speakers to fundraisers and volunteering, I could not be more amazed with everything that has been offered to me through the STEM program."*

As evidenced by the testimonials and evaluations depicted in Section 6, it is apparent that the peer-mentoring activities has had an enormous impact in the scholars' transition from high school to college.

3. The Impact of Faculty Mentoring

Faculty engagement with students is particularly important in the STEM fields. PSH has developed a one-on-one faculty mentoring plan to help keep our STEM scholars engaged with assigned faculty mentors. Our scholars are assigned faculty mentors in their first year. The mentors include both male and female faculty from computer science, environmental engineering, mathematics, electrical engineering, civil engineering, mechanical engineering, and biology. While these mentors are typically chosen from the student's field of study if possible, there are a few with mentors from areas closely related to the scholar's chosen major.

Faculty members are asked to meet with their mentees at least once a month. It proved difficult for students to find time to schedule meetings if we over-programed the mentoring plan, and we found once a month was the minimal number of meetings to be effective. Overall, this past year, the faculty mentors made the mentees feel welcome, answered questions about "college life," helped with course planning and registration, provided timely feedback, assisted with setting curricular goals, provided emotional support and encouragement, assisted in providing options to help solve problems, served as role models and advocates, and helped find extracurricular activities for the students.

Preliminary reports from faculty mentors indicated they met with their mentees monthly, missing perhaps 1 or 2 meetings. Two mentors expressed concern regarding the difficulty in meeting with mentees, mainly that mentees did not show up for meetings. (This is a challenge that we need to investigate. A possible solution might be to set up all meetings with "mini-agendas" to help the student understand the purpose of the meetings, also requiring them to come prepared. Another approach may be to allow the students to "self-select" faculty mentors.) Two-thirds of the mentors interviewed indicated that they had discussed topics beyond simple advising, and described conversations they had with mentees regarding professional organizations, internships, conferences, and potential research areas. One-third had worked with a mentee on explaining, locating, and helping students get into REUs for summer.

Our plan is to continue the faculty mentoring plan for scholars in subsequent years, with slight changes. While this program will still provide the support and encouragement it did for the first year scholars, the focus will be on personal and professional development, including helping the scholar make professional contacts, encouraging them to participate in professional activities, and helping them make professional contacts. In addition, our plan is to allow the scholars to self-identify faculty mentors with whom they would like to work in hopes that this may help promote more mentor/mentee meetings. One of the enormous by-products of the faculty mentors

is that students tended to engage in undergraduate research with faculty mentors or other professors identified by faculty mentors. In this regard, several students were co-authors of papers that were presented in national conferences or technical journals.

- 3 technical papers in a Dentistry Journal
- 1 paper in the West Coast Biological Sciences Undergraduate Research (WCBSUR) Conference, Point Loma Nazarene University, April 25, 2015.
- 1 paper at the 52nd AIAA/SAE/ASEE Joint Propulsion Conference, AIAA Propulsion and Energy Forum and Exposition 2016
- 2 papers in the 46th AIAA Fluid Dynamics Conference, AIAA AVIATION Forum
- 1 paper in 2016 USENIX Annual Technical Conference (USENIX ATC '16).

Positive reviews were also received from the NSF STEM scholars, as one stated *"I met with my Faculty Mentor, Dr. Vidalis who is an Associate Professor of Civil Engineering. I plan on being a Civil Engineer as well. Dr. Vidalis gave me a lot of useful information of clubs and activities at Penn State Harrisburg which will help me out with Civil Engineering and get experience."* Another stated *"The faculty mentor has also helped me to schedule my classes in a way that allows me to stay on course for my program. One of the most critical tasks that the faculty mentor has helped me with was setting me up with another faculty mentor who does research in the areas of my interest."*

4. The Impact of Industry Mentors

Industry mentoring is an essential component for the STEM scholars. The NSF STEM program has not only connected STEM scholars with an industry mentor, but has also brought in guest speakers so that they can share their experiences with the students. This has helped the STEM scholars to interface with employers and industry leaders who understand what is required to be successful in a chosen field. Industry mentors were selected based on their work, skills, and knowledge. They are typically from companies and agencies that already have a relationship with PSH's STEM programs.

In addition, the STEM scholars have gone on field trips and met a variety of professionals, including scientists, engineers, and product developers. These professionals shared their career areas, work experiences, and how they become who they are today.

The NSF STEM Program foresees the industry mentoring to be most effective in the scholars' subsequent years. The program continues to pair each scholar with an industry professional who can not only provide an external point of view, but who can also help identify and develop any necessary technical skills. The continuous commitment of the professionals sharing their time and knowledge with the STEM Scholars has been invaluable. It has also given the STEM scholars the opportunity for internships and full-time jobs after graduation.

4.1 Partnering with Industry to Facilitate Mentoring

As part of connecting the scholars with industry and to facilitate industrial mentoring, the PIs invited speakers from local companies. As an example of such effort, speakers from TE Connectivity, a 15 Billion dollar local company, were invited to the NSF STEM club meetings, where scholars had the chance to network with them. The Director of Multicultural Recruitment

and Community Affairs also planned a visit to the Hershey Foods Technical Center for STEM scholars. Twelve scientist and engineers participated in an open forum sharing their career paths as well as opportunities that exist for students.

Other activities included the following talks:

- "Achievement Stems from Persistence" by Victoria Judd, depicted in Figure 2, who is a Supervisor of Test Engineering at the TE Connectivity.
- "Day-to-Day Operations on Large Corporation" by Sara Bolha, TE Connectivity Mechanical/Project Engineer. Sara is a robotic automation project engineer in TE Connectivity's Global Technology group. She is responsible for design and implementation of flexible automated cells for TE Connectivity's 80+ North America and EMEA production facilities.
- "Experiences of Female Civil Engineers in the Workplace" by Ms. Amanda Hess, Senior Project Engineer; and Ms. Kate Aulenbach, Hydrologic and Hydraulic Engineer, Gannett Fleming, Inc, a civil engineering company in Central Pennsylvania.
- "Real Challenges Engineers Face in the Workplace - Working with People," by Ms. Ms. Rachel Smithers. Area Manager, ArcelorMittal Steelton, LLC. Ms. Rachel Smithers received her undergraduate degree in Materials Science and Engineering from Johns Hopkins University in 1995.

Fig. 2: NSF STEM scholars at a speaking session with Ms. Victoria Judd, TE Connectivity Engineer.

Again, NSF STEM scholars expressed their deep appreciation for this industrial mentoring. Some quotes from the NSF STEM scholars' journals include: *"The STEM Scholars Program has helped me in a few ways to have a better start in my college career. The STEM meetings have provided me with new opportunities financially and also academically. As a part of the program, there is a mentorship program to help students with their walk through college. Through the guidance of attending these meetings, I have become a better student."* In mentioning the impact of mentoring, one scholar stated *"The assigned STEM mentor has been tremendous in answering any questions and always being available through email and face-to-face appointments if*

needed. I could not be more thankful for the accountable staff always being available while pushing us to strive for the highest level of success."

5. The Learning Center Activities

The Learning Center at PSH and its staff continue to offer the following workshops for the NSF STEM scholars:

- Time Management
- Test Taking Strategies
- Test Preparation
- Academic Reading and Comprehension

These workshops are targeted to students in the lower range (between 3.00 to 3.5) of the required GPA to maintain the scholarship. However, all NSF STEM scholars were encouraged to visit the Learning Center if they faced academic challenges. The following interventions were reported in the latest cohort of NSF STEM students who currently are receiving the scholarships. The older NSF STEM cohorts needed minimal Learning Center intervention; hence they are not depicted in the Table I below.

Table 1: Fall 15 Cohort (latest Cohort of NSF STEM scholars), FA 15-SP 16 Academic Year

	High School Index[2]	GPA	Tutoring Appointments	Academic Coach & Learning Center Workshops	Total by Student
Recipient 1	3.38	3.94	0	2	2
Recipient 2	3.34	3.88	0	2	2
Recipient 3	2.87	3.80	2	1	3
Recipient 4	3.21	3.79	0	3	3
Recipient 5	2.87	3.63	39	11	50
Recipient 6	3.08	3.63	0	2	2
Recipient 7	3.39	3.55	7	2	9
Recipient 8	2.89	3.54	10	1	11
Recipient 9	2.85	3.13	0	1	1
Recipient 10	N/A	3.09	5	0	5
Recipient 11	2.88	2.93	0	2	2
Recipient 12	3.17	2.81	2	1	3
Recipient 13	2.93	2.71	0	1	1
Recipient 14	3.32	3.82	0	0	0

From the above table, it is clear that the majority of NSF STEM scholars who sought assistance from the Learning Center in terms of academic learning workshops or study skills had positive transition from high school to college academics. It is important to note, from the above table, that two scholars who heavily sought assistance from the Learning Center had a marked

[2] Average of science and no-science indices

improvement in their performance. The mentoring, coupled with the above Learning Center interventions, overall has had a positive impact in the new cohort of STEM scholars.

6. Mentoring Evaluations

Peer mentoring evaluations were carried out the first semester a new cohort came into NSF Scholars program. The assessment surveys were created from a combination of the Assessing Women and Men in Engineering (AWE) program[16] and the Motivated Strategies for Learning Questionnaire (MSLQ)[17] and designed to measure the learning strategies of STEM students. To check the efficacy of the mentoring program, the anonymous surveys were taken at three different times during the semester: before the mentoring started, half-way through the semester, and at the end. Table II below shows the results of the evaluation of the survey tool. The participants were 45% female and 55% male; they identified as 10% Hispanic/Latina/Latino; 60% White American; 17.5% Black/African American; 7.5% Asian and Pacific American; and 5% other. Each statement has range value of 1 (minimum) to 6 (maximum); each column depicts the average value of the responses.

Table II: Results of mentee survey at three different times
Question 3: How much do you agree with each of the statements below?

	Pre-Mentoring	Mid-Semester	End-Semester
a) When I participate in STEM professional societies or other extracurricular activities, I feel welcome.	5.25	5.58	5.81
b) I enjoy working with other students on group work outside of classes.	5.00	5.42	5.35
c) I attend (or intend to attend) faculty office hours at least once a week.	4.71	4.21	4.17
d) My academic program offers me the support and help when I need it.	5.38	5.32	5.81
e) I have many friends who are studying in my field.	4.50	4.96	4.92
f) Some faculty members know me by name.	4.88	5.48	5.60
g) I have family members or close family friends who are engineers or scientists.	3.88	3.60	4.17
h) I prefer course material that really challenges me so I can learn new things.	5.38	4.93	5.50
i) Getting good grades in my classes is the most satisfying thing for me right now.	5.88	5.73	5.65
j) I want to do well in my classes because it is important to show my ability to my family, friends, employer, or others.	5.88	5.84	5.58
k) If I can, I want to get better grades than most of the other students in my classes.	5.75	5.68	5.62
l) I prefer course material that arouses my curiosity, even if it is difficult to learn.	5.75	5.64	5.31
m) If I study in appropriate ways, then I will be able to learn my class materials.	5.75	5.83	5.81

n) If I try hard enough, then I will understand my class materials.	5.75	5.43	5.48
o) The most satisfying thing for me in this course is trying to understand the content as thoroughly as possible.	5.50	5.56	5.52
p) The most important thing for me right now is improving my overall grade point average, so my main concern is getting a good grade.	5.63	5.58	5.65
q) When I have the opportunity, I choose course assignments that I can learn from even if they don't guarantee a good grade.	5.13	4.74	4.94
r) I usually study in a place where I could concentrate on my course work.	5.63	5.57	5.50
s) Even if I had trouble learning the material in my classes, I tried to do the work on my own, without the help of anyone.	4.75	4.59	4.52
t) I attend class regularly.	6.00	5.89	5.88
u) When studying for a class, I often try to explain the material to a classmate or friend.	5.00	4.83	4.90
v) I ask the instructor to clarify class concepts I do not understand well.	5.25	5.32	5.48
w) I made good use of my study time.	5.13	5.00	4.90
x) I try to work with other students from my classes to complete the course assignments.	5.38	4.86	5.06
y) I often find that I did not spend very much time on my classwork because of other activities.	3.63	4.09	3.46
z) I find it hard to stick to a study schedule.	3.92	4.43	3.63
aa) When studying for my classes, I often set aside time to discuss the course material with a group of students from the class.	4.38	4.06	4.58
bb) When I cannot understand class material, I asked another student for help.	5.88	5.05	4.94
cc) I have a regular place set aside for studying.	5.00	4.94	5.50
dd) I rarely find time to review my notes/the textbook before an exam.	2.88	3.16	3.23
ee) I make sure I keep up with the weekly readings and assignments for my classes.	5.38	5.27	5.46
ff) I try to identify students in my classes whom I can ask for help if necessary.	5.63	5.49	5.19
gg) It is my own fault if I don't learn the material in my classes.	5.88	4.90	4.92
hh) If I don't understand class materials, it is because I didn't try hard enough.	4.00	4.45	4.79

In statements relating directly to peer mentoring (a, b, d, e and aa), the average of the survey shows improvement, as the PIs tried to pair the mentees early in the semester. In statements regarding performance in the classroom, the ratings remained the same or show a slightly decrease.

We also surveyed the peer mentors to examine the efficacy of the mentoring program on themselves. Table III summarizes the results.

Table III: Results of peer-mentor survey at 3 different times
Question 3: How much do you agree with each of the statements below?

	Pre-Mentoring	Mid-Semester	End-Semester
a) When I participate in STEM professional societies or other extracurricular activities, I feel welcome.	4.57	6.00	6.00
b) I enjoy working with other students on group work outside of classes.	5.57	5.40	6.00
c) I attend (or intend to attend) faculty office hours at least once a week.	3.86	3.80	4.50
d) My academic program offers me the support and help when I need it.	5.57	5.60	6.00
e) I have many friends who are studying in my field.	5.43	5.20	5.50
f) Some faculty members know me by name.	6.00	6.00	6.00
g) I have family members or close family friends who are engineers or scientists.	5.29	4.40	4.00
h) I prefer course material that really challenges me so I can learn new things.	5.43	5.60	5.00
i) Getting good grades in my classes is the most satisfying thing for me right now.	5.43	6.00	6.00
j) I want to do well in my classes because it is important to show my ability to my family, friends, employer, or others.	5.29	5.80	6.00
k) If I can, I want to get better grades than most of the other students in my classes.	5.57	5.80	6.00
l) I prefer course material that arouses my curiosity, even if it is difficult to learn.	5.86	5.20	5.00
m) If I study in appropriate ways, then I will be able to learn my class materials.	6.00	5.75	5.50
n) If I try hard enough, then I will understand my class materials.	5.71	5.80	5.50
o) The most satisfying thing for me in this course is trying to understand the content as thoroughly as possible.	5.43	5.80	6.00
p) The most important thing for me right now is improving my overall grade point average, so my main concern is getting a good grade.	5.29	6.00	6.00
q) When I have the opportunity, I choose course assignments that I can learn from even if they don't guarantee a good grade.	4.71	4.40	5.00
r) I usually study in a place where I could concentrate on my course work.	5.71	5.00	6.00
s) Even if I had trouble learning the material in my classes, I tried to do the work on my own, without the help of anyone.	5.00	5.00	4.50

t) I attend class regularly.	6.00	5.80	6.00
u) When studying for a class, I often try to explain the material to a classmate or friend.	5.29	5.20	5.50
v) I ask the instructor to clarify class concepts I do not understand well.	5.00	5.80	6.00
w) I made good use of my study time.	5.29	5.40	5.50
x) I try to work with other students from my classes to complete the course assignments.	5.29	5.20	6.00
y) I often find that I did not spend very much time on my classwork because of other activities.	4.00	4.40	5.00
z) I find it hard to stick to a study schedule.	4.14	5.00	4.50
aa) When studying for my classes, I often set aside time to discuss the course material with a group of students from the class.	4.14	4.80	5.00
bb) When I cannot understand class material, I asked another student for help.	4.57	5.00	6.00
cc) I have a regular place set aside for studying.	4.43	5.00	5.00
dd) I rarely find time to review my notes/the textbook before an exam.	2.86	3.60	3.50
ee) I make sure I keep up with the weekly readings and assignments for my classes.	4.29	4.60	3.00
ff) I try to identify students in my classes whom I can ask for help if necessary.	4.57	5.60	6.00
gg) It is my own fault if I don't learn the material in my classes.	4.71	5.40	5.50
hh) If I don't understand class materials, it is because I didn't try hard enough.	4.14	4.80	4.50

As is clearly shown in the above results, the peer mentoring has also had a positive impact on the peer mentors themselves.

7. Summary and Conclusions

The NSF STEM Scholarship Program continues to be a big draw for this university, as the Director of Admissions reports an increase of engineering and science applications. The customized mentoring plan and support services have had a positive impact in the academic and social life of the NSF STEM scholars. We are pleased to report, from the first two cohorts that went through this NSF STEM program, the following accomplishments so far:

- One student accepted at a medical school
- One scholar accepted in a physician assistant program
- One accepted in the Masters in Health Administration
- Two scholars preparing to take the Medical College Admission Tests
- One scholar secured a high profile internship in J.P. Morgan Bank in information technology
- Another one secured a sought-after internship in Exxon Mobil
- Others secured well-paying jobs in engineering firms

The current cohorts are involved in a variety of activities such as REU summer research and various internships, as well as publishing papers in conference or in journals.

In summary, as depicted by the testimonials, the results of assessing the peer mentoring, undergraduate research output, and post-graduation placement, our NSF STEM program, coupled with well-designed support services, helps students successfully complete their undergraduate studies and secure a bright future for themselves. Further longitudinal assessments are forthcoming.

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