

Using Mid-Semester Evaluations for Increasing Success of STEM Students: A Case-Study

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Increasing persistence and graduation of post-secondary STEM students is a topic of significant focus and research, as are strategies for identifying barriers to success and intervening to bridge related gaps. In the case of underrepresented students, there are many challenges that may impact persistence in STEM majors, many of which, while manifesting as academic failure, are not directly related to academics. Thus, it is important not only to develop mechanisms for recognizing when students are in danger of failing courses, but to also establish a support structure for intervention that ascertains and addresses a variety of possible causes. This article describes a strategy for increasing student success and indicates some of the successes, some of the failures, and some of the challenges involved in conducting a mid-semester evaluation as part of a National Science Foundation Scholarships in STEM (S-STEM) project. Students for our S-STEM project were selected from juniors and seniors with significant unmet financial need primarily on the basis of academic ability with specific effort placed on supporting students from demographic groups underrepresented in STEM majors.

Background

As our world becomes increasingly interconnected, the pace of technological advance accelerates, and the global context and complexity of challenges faced by society increases, diverse and well-qualified STEM professionals are in high demand. The demand for more qualified STEM professionals and need for increased recruitment, retention, and graduation of STEM majors is well documented (President's Council of Advisors on Science and Technology, 2012) (*Rising Above the Gathering Storm*, 2005) (Neuhauser & Cook, 2016). While there is debate as to whether the need for STEM professionals is across the board or in specific disciplines, job market analysis continues to show significant challenges for the US (Anft, 2013) (Xue & Larson, 2015) (New American Economy, 2017). Review of online job postings shows that in 2010, 5.4 STEM jobs were posted for every 1 unemployed STEM professional (New American Economy, 2017). This grew to a staggering 13 unfilled jobs for every unemployed STEM professional in 2016, with some states seeing more than 50 STEM jobs posted for every one qualified, unemployed

individual (New American Economy, 2017).

Thus, a focus on persistence and graduation is of interest for increasing success of all STEM majors but, is particularly important for students from traditionally underrepresented groups. These students may face different challenges and may be less likely to seek support in order to remain in their STEM major (Litzler, Samuelson, & Lohr, 2014) (Cohen & Garcia, 2008) (Kendricks, Nedunuri, & Arment, 2013). Some of the most significant barriers to persistence include sense of community, STEM identity, academic preparation, and financial or family stress (Toven-Lindsey, Levis-Fitzgerald, Barber, & Hasson, 2015) (Estrada et al., 2016) (Dagley, Georgiopoulos, Reece, & Young, 2016). Targeted interventions are needed to address the variety of barriers that students face as they pursue STEM majors.

A variety of intervention strategies designed to increase STEM student persistence and graduation have been developed and studied. Successful interventions typically focus on a multitude of approaches considering the variety of barriers that underrepresented students may face. Dyer-Barr (2014) reviewed STEM intervention programs in 10 institutions and found commonalities among successful programs including focus on individual student needs, collaboration across campus units to ensure students are connected to all available resources, and creating supportive communities that enable students to thrive. In particular, most successful intervention programs address financial, academic, and community/confidence elements to provide comprehensive support to students (National Academy of Sciences, 2011) (Hanover Research, 2011) (Carver et al., 2017) (Cleveland State University implemented a comprehensive program, called Operation STEM (Windsor et al., 2015 et al., 2015). In the case of underrepresented students, financial and social struggles are often just as significant or even more so than academic challenges.

S-STEM Program Description

The NSF S-STEM program makes grants to institutions of higher education to support scholarships for academically talented, financially needy students, enabling them to enter the workforce following completion of an

associate; baccalaureate; or graduate-level degree in science and engineering disciplines. There is considerable latitude in the design of a scholarship program for each institution.

This S-STEM project was implemented at the University of Memphis, a large metropolitan research university serving over 20,000 students. The student body is very diverse, with approximately 50% White, 34% Black, 5% Hispanic, 5% Asian, and 6% students of other ethnicities. The College of Arts and Sciences offers STEM degree programs in mathematics, chemistry, biology, physics, earth sciences, and business information technology. The College of Engineering offers undergraduate and graduate programs in biomedical engineering, civil engineering, computer engineering, electrical engineering, mechanical engineering, and engineering technology.

For our program, interventions were designed to address three core areas of need: financial, academic, and social. Students for the S-STEM had to have unmet financial need according to their Free Application for Federal Student Aid (FAFSA) in order to qualify for the scholarship and most qualified to the full amount, indicating greater than \$5000 annual unmet need. Financial support was delivered through the scholarship itself and through financial counseling provided by our staff counselor. Academic support was provided through employing private tutors. Typically, tutors were employed to assist students in groups with select upper division courses. Students reported that University-provided tutoring only addressed the lower division courses, with which they had not struggled. University resources were not available to support specialized upper-division STEM courses, thus our intervention provided tutoring services to address this gap. The social aspect of the program involved creating networking opportunities for students with both peers and professors in their discipline, through informal gatherings. In an earlier NSF supported STEM Talent Expansion Program this intervention was more powerful than any other in retaining students in their major (Windsor et al., 2015 et al., 2015). Our student body in general, and our S-STEM recipients in particular, are largely commuter students who are only on campus for scheduled classes and laboratories. In Fall 2016, 95% of Junior and Senior STEM majors lived off-campus. This hampers community

formation, which is especially detrimental to success in upper division STEM courses. Finally, our interventions included a mid-semester evaluation administered to faculty teaching S-STEM students to identify those at risk of failing courses so that key challenges could be identified, and students could be connected to support services.

For our S-STEM program, we originally planned to recruit two cohorts of 16 students each. Students were expected to be recruited as rising Juniors then be supported for up to three years. Applications were invited via a Qualtrics form that solicited the following information: name, ID number, address, major, GPA, semester standing, outside employment, and a brief personal statement. Originally, we asked for letters of recommendation but dropped this requirement after the first round of applications. The letters did not yield actionable information and we found that asking a representative from the student's discipline to rank the students provided better insight.

The program ran for 5 years and supported a total of 71 students. Table 1 shows the demographics of the S-STEM recipients.

Determining the ethnic diversity of the cohort is complicated by the number of recipients who elected not to declare their race. The proportion of female recipients in our S-STEM cohort was unambiguously higher than appropriately weighted proportion of female students in the STEM departments that our scholarship recipients came from. The percentage of female students in STEM majors in Arts and Sciences at our institution ranges from approximately 29% (physics) - 62% (biology) and Engineering ranges from 6% (engineering technology) - 45% (biomedical engineering), depending on the specific degree program (example enrollment statistics are from Fall 2016 undergraduate STEM majors).

Methodology for Mid-Semester Evaluation

The mid-semester evaluation was designed to provide early warning that students in our S-STEM cohort were struggling in their classes. This included determining how students were performing on exams, whether or not they were completing class assignments, and attendance patterns. The following methodology evolved over the course of the project:

1. At the start of the second week of classes we would pull a list of all courses being taken by our S-STEM recipients.

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a. From this list, we removed 0 credit hour courses (at our institution these are used by science courses that have multiple lab sections but include the lab hours in the main course and give only a single grade for the combined lecture and lab course).

b. From this list, we removed multiple entries for courses that met outside of standard scheduling.

c. Finally, we converted the list from a long form, with one entry per student per section, to a wide form, with one entry per section.

2. We used the converted list to send one email per section identifying the instructor, the course, the meeting time and listing the S-STEM recipients in the section and their institutional emails. This email was sent from the PI's institutional email. The purpose of the email was three-fold:

a. Request that the instructor confirm with the students that they had authorized the release of information regarding their performance in class.

b. Request that instructors contact us if any of the S-STEM students in their sections encounter difficulties.

c. Indicate that we would contact them for a mid-semester evaluation and that this email would come from the Qualtrics survey service and not from an institutional email address.

3. Two weeks prior to the late-drop deadline we repeated Step 1, in order to remove entries for any recipient that had dropped a section already.

4. We used the converted list to send one email per section:

Dear Professor [Last Name]

The following students in your [Course and section number] course are recipients of an S-STEM scholarship, please see [Link] for further information.

[List of students and their institutional emails]

As part of this scholarship they agree to allow us to request mid-semester evaluations from their professors. You should feel free to confirm this with your students. For convenience, their email addresses are given above.

You will shortly receive a survey link for each of the S-STEM recipients in your section. The survey is extremely brief and should take at most one minute

to complete. This email will come from noreply@qualtrics-research.com, which belongs to Qualtrics, the University's survey provider. Your honest feedback on the students is highly appreciated. We employ a professional counselor and can employ tutors for our students. In the case of a concern we can provide support to your student that may alter their trajectory.

If you feel like this email reached you in error, for example, your course is a laboratory course for which no separate grade is assigned, then please do not hesitate to respond and I will ensure that no mid-semester evaluation is sent.

This email was sent from the PI's institutional email.
5. The long form of the email list was uploaded into the Qualtrics survey service as a panel and the survey was distributed via email with a unique link for each student:

Dear Professor [Professor last name],

S-STEM is a National Science Foundation funded scholarship program for STEM students that are excelling academically despite being in financial need. [Student name] is the recipient of an S-STEM scholarship and has Windsor et al., 2015 sized a release allowing us to request this mid-semester evaluation. [Student name] is a student in your [course name] class that meets on [class time] in [location].

You should feel free to ask the student to confirm this by emailing them at [student institutional email].

The purpose of the mid-semester evaluation is to connect the student with academic assistance if they require it.

Please follow the link below to complete a very short evaluation of [student name].

Take the Survey

Or copy and paste the URL below into your internet browser:

[Survey Link]

We appreciate your time.

This email came from noreply@qualtrics-research.com. Unfortunately, our institution did not have the facility to have the Qualtrics emails come from an institutional address. The survey was distributed the day after our initial notification email. We distributed one reminder at the start of the following week. We would suggest sending a second reminder the day before the drop deadline.

This procedure evolved to address three concerns:

1. Complaints about email bombardment from early distributions.
2. Concerns about student privacy.
3. Concerns about survey emails from a non-institutional email address.

The timing of the "mid-semester" evaluation turned out to be problematic. Distributed too early and many instructors indicated that they did not have sufficient in-

Ethnicity			Gender		
Asian	8	11%	Female	27	38%
Black or African American	13	18%	Male	44	62%
White	34	48%			
Not Reported or Unknown Race	16	23%			

Table 1. S-STEM Cohort Demographics

formation to make an informed decision and our response rate was low. Distributed too late and there was too little time to take successful corrective actions. Looking over our response rates, we suggest a date two weeks prior to the late drop deadline at an institution (the last opportunity to withdraw from a course) with two reminders, one a week prior to the late drop deadline, and one a day prior to the late drop deadline. In many courses, it appears that instructors view this as the deadline to provide students with significant feedback so there are many mid-term examinations in the week prior to this deadline. Our reminders are generated within the Qualtrics platform and are only sent to the instructors who have not completed their evaluation. During the project, we sent either no reminder or one reminder, this was following lots of complaints about multiple emails early in the project. We recommend sending two reminders. Our initial assumption was that most instructors who did not respond did so because there was no reason for concern. Subsequently, this has not been borne out.

The Mid-Semester Evaluation Instrument

Surveys were distributed using our Qualtrics survey platform. Each instructor received an email that personally identified them, the section that they were teaching, and the student for whom we were requesting the evaluation. The email specified that the evaluation would consist of a single question if there were no concerns and four questions if the instructor had concerns. The email contained a unique link to a survey. This survey identified the course and the student automatically and consisted of a single question

Dear Professor [Last name],

The following questions refer to [student name] who is a student in your class [class] that meets in [location] at [time]. [student name] is the recipient of an S-STEM scholarship and had signed a release allowing us to request a mid-semester evaluation of them from you.

You should feel free to ask the student to confirm this by emailing them at [student institutional email].

Yours sincerely,

Are there reasons for concern over [student name]'s performance in your class this semester?

If you answer No then the survey will end. If you answer Yes, then there will be 4 follow-up questions.

Yes No

Term	Sent	Completed	Rate	Concerns	Reminder
Spring 2013	105	73	70%	8	Yes
Fall 2013	175	129	74%	20	Yes
Spring 2014	168	73	43%	7	No
Fall 2014	156	126	81%	10	Yes
Spring 2015	110	69	63%	3	Yes
Fall 2015	94	35	37%	5	No
Spring 2016	65	30	46%	1	No
Fall 2016	51	25	49%	3	No

Table 2. Summary of Distributions

Scholarships in STEM

College of Arts & Sciences

S-STEM Mid-Semester Evaluation Form

We made No the default so that an instructor can complete the survey with a single click if there are no issues. If the instructor answered in the affirmative, then they received the following four-question follow up:

Please indicate the reasons for your concern over [student name]'s performance:

- Failure to attend class.
- Failure to complete assigned work.
- Performance on assessed work.
- Performance on exams.

Please give a brief description of your reasons for concern over [student name]'s performance:

Please give your suggestions for what [student name] can do to address their poor performance:

Please give details of any tutoring programs that are available and any opportunities for extra credit open to the students:

Any evaluation submitted that indicated there was concern about the student's performance generated an immediate email notification that went to two faculty members and to our professional counselor. Our counselor would work with students and refer them to the PI if the problem was deemed to be academic and additional support was requested. If the counselor deemed the issue to be non-academic then the counselor worked with the students confidentially and the rest of the team did not get reports. The majority of the issues that arose were non-academic. Typically, where academic issues arose, the

students would contact the PI early in the semester.

Results of the Mid-Semester Evaluation

Table 2, above, summarizes the distribution of our mid-semester evaluations.

Our response rate overall was 74% when a reminder was sent and 43% when a reminder was not. Moreover, the percentage of concerns raised averaged 8% of the total distribution when a reminder was sent and 4% when a reminder was not sent. We recommend sending a reminder. In Fall 2015 the evaluation was not sent out until after the late drop deadline.

Table 3 summarizes the responses to our mid-semester evaluation. Unfortunately, many problems went unreported. In some cases, through accidents of timing or coding or for students taking online courses through other institutions, some instructors did not receive emails. Initially, perhaps naively, we assumed that instructors who did not respond did not have concerns. This may have been the case, but the data reveals that these instructors should have had concerns. During the 5 years of the grant there were 36 failing grades out of 945 recorded grades. Most failing grades were obtained in courses where the instructor failed to respond to the survey. Though this category only accounted for 35% of responses it accounted for 53% of failing grades. The effectiveness of the evaluation itself is clear; the percentage of D and F grades in courses where instructors completed a mid-semester evaluation (2.1%) was lower than that in courses where a mid-semester evaluation was not completed (5.8%) and this difference is statistically significant ($p=0.004$). The DFW rate in courses where instructors completed a mid-semester evaluation (4%) was lower than that in courses where a mid-semester evaluation was not completed

Mid-Semester Evaluation						
Outcome	Concerns	No Concerns	No Response	Not Surveyed	Total	
Pass	46	466	307	72	891	
DF	8	3	19	6	36	
W	2	8	2	6	18	
Total	56	477	328	84	945	

Table 3. Outcome for Students by Mid-Semester Evaluation Response

(6.4%) but this difference was not statistically significant ($p=0.103$). The authors acknowledge that there may be confounding factors that are simultaneously affecting students' success and whether an instructor completes the mid-semester evaluation so that the improved results cannot be unambiguously assigned to the effect of the mid-semester evaluation and subsequent interventions. Of the 56 classes in which concerns were raised about student's performance and the S-STEM team intervened, 46 classes were passed, 8 were failed, and 2 classes were dropped. Of the 8 failing grades 4 were recorded by a single student. The courses that were not surveyed were unusual in some respect and this may account for the relatively high fail rate.

Indeed, of the 6 failing grades 3 were from off-campus online courses. Given this information we will pay particular attention to surveying these courses in future.

We note that the courses that students received either a grade of D or F, or dropped, were distributed across the University, though only 3 were non-STEM courses. The only course to appear more than twice was Calculus-based Physics 1 (and that included an off-campus online course).

Types of concerns

Table 4 summarizes the responses to the type of concern multiple select question.

Reason	Frequency
Failure to attend class	13
Failure to complete assigned work	8
Performance on assessed work	22
Performance on exams	37
Multiple selections	23

Note: In 23 cases multiple reasons were selected. Those reasons are reflected in the individual reason count.

Table 4 Summary of Reasons for Concern Multiple Select Question

Reasons for concern		Remedies	
Word Stem	Freq.	Bigram	Freq.
exam	57	extra credit	17
class	30	office hours	8
first	24	ask questions	8
grade	21	take advantage	5
score	18	homework assignments	4
miss	17	learning center	4
perform	17	make sure	4
attend	12	tutoring available	3
well	11	attend class	3
homework	11	credit quizzes	3
assign	10	students take	3
final	10	questions class	3
average	10	homework problems	3
		work problems	3
		advantage office	3
		problem sessions	3
		come class	3

Table 5 Analysis of Text Responses to Reasons for Concern and Suggested Remedies

As can be seen the most prevalent concern was about performance and not about attendance or failing to complete assigned work. Failure to attend class was mentioned 5 times independently of other concerns but was most frequently paired with additional concerns. Performance on assessed work actually appeared only 7 times without being paired with performance on exams. Performance on exams appeared as the sole concern 19 times. Failure to complete assigned work only appeared in conjunction with other reasons.

Table 5 summarizes the most common words in the reasons for concern question and the most common bigrams in the remedies question.

The reasons for concern was typically used to provide quantification of the concerns (such as number of classes missed or scores on various assessments). The results from the text mirror those from the multiple select, with terms like exam, score, and grade outweighing terms like attend, miss, homework or assignment. More interesting are the responses to the possible remedies question, which typically address the means by which the grade could be improved (extra credit) or where help may be sought (office hours, learning center, and tutoring available) but relatively few addressing concrete changes to students' behavior (work problems, ask questions, come/attend class).

Results of the overall S-STEM Project

Of the 71 students recruited for the S-STEM, 61 graduated during the project period (including two students who were not full time in their final semester and therefore were not supported), eight were still enrolled in good academic standing when the project ended, and two left the project (one for academic reasons and one for financial reasons). Of the eight who were in good academic standing at the end of Spring 2017, four graduated at the end of Summer 2017, two graduated in Fall 2017, and two filed their intent to graduate for Spring 2018. The student who left for financial reasons has subsequently returned to the University and should graduate in Summer 2018. The student who left the project for academic reasons was recruited during the first semester due to a misunderstanding of whether pre-medical students should be considered clinical. Initially we excluded students from the Biology, Biomedical, or Chemistry majors with a declared pre-medical intention but the NSF informed us that we could award these students (and we did so in subsequent semesters). Unfortunately, the student eventually left the University without graduating.

Discussion

There are several important lessons we learned from this mid-semester feedback. One is that students prioritize

courses; frequently we had instructors indicate concern because a student was performing below where the instructor felt they were capable of performing whereas the student would indicate that there was no need for concern, they were going to pass the course and they were devoting more time to courses that were crucial for their major. Given that our students were typically taking heavy loads and often had other commitments outside of class, we supported their conscious decisions to prioritize other courses. We did consider changing our evaluation to ask whether students were in danger of failing a course but decided that instructor concerns were more valuable and that seeing that a student was in danger of getting lots of B or Cs was very valuable as a warning signal. In future, we will ask for an “expected grade” to help distinguish concerns about which passing grade a student will get from concerns about whether a student will receive a passing grade. Another lesson learned is that we should not try to predict in which courses an individual student will experience difficulty. One engineer nearly failed to graduate by nearly failing a general education theatre arts course, the difficulty was that he had signed up for an 8 am section because it was the only one that fit his schedule, but he was not making it to class. Through the project intervention, he received wake up calls and a passing grade. Thus, we advise that the evaluations should go to all the courses students are taking and not just those in which they are most likely to experience difficulties.

Our final note is that no evaluation, however carefully conducted, will catch everything. Thus, it remains paramount to maintain frequent communication with students. Even then students will experience life issues, be they relationship issues, health issues, or financial issues that they do not wish to share and that do not manifest until final grades are in. In these cases, the best you can do is to identify the problem as early as possible and try to open communications. Sometimes these problems are serious enough that a student will not re-enroll and will disconnect from the University. We had such a case with a student with a very high GPA, who had been working actively with faculty, but who failed two courses, did not re-enroll in school, and was not responding to their emails or telephone calls. A careful examination of their transcript revealed that the student could switch catalogs and graduate with the courses they had already completed. The student was eventually contacted through Facebook and submitted paperwork to receive their degree. The student had experienced financial hardship, had chosen to take on a full-time job expecting to be able to pass their courses but had been unable to manage all of the commitments. As the student had been so heavily involved with faculty, he felt that he had personally failed them, and could not bring himself to return to his Department. Our experience indicates the importance of recognizing the complexities that contribute to performance challenges for STEM students, prioritizing investment of time and resources in

support of student success and developing a broad range of interventions addressing multiple factors that can be barriers to academic achievement. These approaches are key to creating an environment and support structure, tailored to individual institutions, that are effective for increasing STEM student success.

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