Stones in the Road: Analysis and Response to ”Roadblock” Courses in the SEECS Program

Dr. Scott Steinbrink, Gannon University

Dr. Scott Steinbrink is an associate professor of Mechanical Engineering.

Dr. Karinna M Vernaza, Gannon University

Karinna M. Vernaza is a Professor in the Mechanical Engineering Department and Associate Dean of the College of Engineering and Business, Gannon University (Erie, PA). She joined Gannon University in 2003 with primarily teaching responsibilities in the solids mechanics field and introduction to engineering courses. Her academic background includes a B.S. is in Marine Systems Engineering from the U.S. Merchant Marine Academy and a M.S. and Ph.D. in mechanical engineering from the University of Notre Dame; her industry experience includes shipyard project management and consulting for Off-High Vehicles projects for GE Transportation. She was awarded the 2012 ASEE NCS Outstanding Teacher Award, 2013 Gannon University Distinguished Faculty Award and 2013-2014 Gannon University Faculty Award for Excellence in Service-Learning. She is one of the Principal Investigators of three NSF S-STEM and one ADVANCE-PAID grants.

Dr. Barry J Brinkman, Gannon University
Dr. Theresa Vitolo, Gannon University

Theresa M. Vitolo is an Associate Professor (retired) in the Computer and Information Science Department, Gannon University (Erie, PA). Teaching in systems-related fields since 1986, she joined the Computer and Information Science Department at Gannon University in 1999. In addition to teaching, she has worked as a systems analyst / programmer on a variety of systems development projects. Her academic background includes a B.S.E. in industrial engineering and a Ph.D. in information science; her industry experience includes systems analysis and cognitive science applications. She was one of the Principal Investigators on two NSF S-STEM and one NSF ADVANCE-PAID grants. With a life-long interest in technology and its potential for enhancing human capabilities, her research includes advances in analytics, motivated system energetics, and other topics relative to knowledge-intensive systems.

Mr. Adam Finn Nogaj, Gannon University

Stones in the Road: Analysis and Response to "Roadblock" Courses within the SEECS Program

Abstract

The Scholars of Excellence in Engineering and Computer Science (SEECS) program is a National Science Foundation sponsored scholarship granting program at Gannon University. Through the first seven years of scholarship granting (2009 – 2015), SEECS helped 77 students pursue the goal of graduation from college with a STEM degree, specifically a degree in an engineering or computer science related field. This paper analyzes data from current and previous SEECS students confirming previously-published data pointing to "roadblock" courses which most often lead to GPA trouble (i.e. cumulative GPA less than 3.0), and investigates techniques which are or have been implemented to improve student academic success. Strong correlations have been noted between specific letter grade thresholds in identified courses and eventual separation from the SEECS program for low GPA. Intervention strategies for students who have stumbled in one or more roadblock courses, as well as generally-implemented practices conducted by the university and the SEECS program, are discussed. Consideration is given to intervention techniques presented in previously-published literature, with respect to feasibility for inclusion in an honors-type engineering program such as SEECS.

Keywords—academic performance, retention, intervention strategies, academic support

Factors Affecting Retention of STEM Students

A commonly-held perspective within the United States urges for an increased pool of qualified workers in the STEM fields. Aligned to the perception is the conviction that the number of STEM-major students in universities is far short of the projected demand for STEM workers. In response to this problem, the National Science Foundation (NSF) has created the program "Scholarships in Science, Technology, Engineering and Mathematics (S-STEM)" seeking to increase the number of domestic students in STEM fields by providing financial support to promising students who have limited financial means. The SEECS program, detailed in the next section, is one program sponsored by the NSF through the S-STEM grant program. S-STEM addresses one side of the problem: The number of STEM students is increased by providing lower-income students with the financial wherewithal to enter into STEM studies. The funding does not directly address another key problem of graduating STEM majors: attrition of matriculated students.

Causes of attrition among STEM students have been the subject of numerous studies [1, 2]. An excellent survey of those studies and their conclusions has been provided by Geisinger and Raman [1]. The paper reviewed 50 studies addressing reasons for student attrition, supplemented by 25 additional studies of methods attempted to improve retention. The major causes of attrition are reported to be (1) an unwelcoming academic climate, (2) conceptual difficulty with core courses, (3) lack of self-efficacy or self-confidence, (4) inadequate high school preparation, (5) insufficient interest or commitment to engineering or a change in career

goals, or (6) racism or sexism within the field. The SEECS program already has programmatic features which address three of these stated attrition factors, namely (1), (3), and (5). Furthermore, the selection of students for participation in SEECS in part eliminates factor (4).

SEECS does, however, suffer attrition related to factor (2), conceptual difficulty in foundational courses. In particular, the SEECS faculty members have noted student performances in the first calculus and physics courses are strongly correlated with eventual dismissal from the SEECS program due to poor GPA (i.e. defined, for SEECS membership, as below 3.0). This observation seems to be corroborative of previous work; 23 of the studies cited in [1] report factor (2) as a significant source of attrition. Difficulty in foundational courses poses a series of roadblocks – multiple stones in the road – hindering a student's progress to graduation. If help can be given to the student to remove the stones blocking their progress, the educational goals of the student may be reached.

The SEECS Program: Scope and Structure

The Scholars of Excellence in Engineering and Computer Science (SEECS) program at Gannon University is a National Science Foundation S-STEM scholarship program [3], awarded through the Division of Undergraduate Education S-STEM program. The S-STEM program seeks to increase domestic representation in STEM fields by offering tuition assistance to US citizens and other eligible permanent US residents. Scholarship recipients are required to demonstrate both academic merit and financial need. Scholarship amounts have varied from year to year and sometimes from student to student, but the program has been awarded approximately $1.1M in scholarship funds to date.

SEECS uses a seminar-based instruction method to provide professional and personal development opportunities and practical design experience as a means to create a professional learning community and to prepare students to succeed post-graduation. The community includes students of all majors within the School of Engineering and Computer Science and of all academic levels. Activities enable students to work together across disciplines and across levels. Anecdotal evidence portrays the efforts of the SEECS program as being very helpful in preparing students for life after graduation.

Specific requirements for receipt of SEECS scholarship funds include a minimum GPA of 3.0, measured with respect to core classes of the student's discipline only. The requirement for a high GPA level is in response to the "academic merit" provision of the NSF S-STEM goal and promotes the image of participation in the SEECS program as a mark of distinction among students. In conjunction with the NSF provision, a 3.0 GPA is typically the minimum GPA required for internships. Preparing students for professional endeavors such as internships is at the heart of SEECS; therefore, the requirement enables students to be competitive.

One of the three goals of SEECS is: "through a program of scholarships and rigorous academic support, assist students to continue their STEM education through graduation." But this goal has not been met for all SEECS students. In particular, SEECS scholarships have had to be revoked in several cases due to student failure to maintain a minimum 3.0 GPA.

Note, while SEECS demonstrates a number of characteristics that are defined hallmarks of an honors program [4], SEECS is not so designated by the university or by NSF. SEECS is viewed by students and SEECS faculty members as an "honor," and students are recognized at commencements in a way similar to receipt of a cum laude designation, but it carries no designation on student transcripts or diplomas. A comparison of SEECS to engineering honors programs at other universities, in fact, shows significant differences in the level of faculty-student interaction and the level of attention spent to provide personal and professional growth, and in the prominent presence of intervention strategies used to assist students to maintain high GPA. Hence, given this nature of the program, SEECS is a one-of-a-kind program.

Total Student Enrollment in SEECS

Through the first seven years of SEECS funding, a total of 147 one-year scholarships were awarded to a total of 77 students. Continuance of the scholarship is guaranteed so long as the student remains in good standing.

In the first year of awarding, 12 scholarships were granted to existing Gannon students at the sophomore level and above in order to create a fully populated SEECS community and to realize the strategies of the grant. When necessary to maintain class and major balance, additional scholarships have been awarded to qualified Gannon students from outside SEECS. A total of nine additional non-freshman students were added to meet this goal. After the first year, most scholarships have been awarded to incoming freshmen. Of the 77 scholarship recipients, 56 are students who entered the program as freshmen. As of the end of the 2015-2016 academic year, 30 of those students have graduated as SEECS members, 6 have lost eligibility due to insufficient GPA, and 22 were still in the program making progress towards graduation.

Assessment Based upon GPA

Vernaza et al. [5] previously presented data indicating that, of high school GPA and SAT/ACT scores, GPA is a far better predictor of successful completion of the SEECS program. The finding has led the current authors to view college GPA as the best available predictor of eventual SEECS completion. Working from that perspective, a qualitative study of particular grades in courses taken as college students has been undertaken to determine whether specific courses are more or less impactful on GPA than others. This study included all SEECS students admitted as freshmen or sophomores between fall 2009 and fall 2014. Students admitted at higher than sophomore level and students admitted beginning in fall 2015 are omitted from the analysis. That is, the study included only students who had completed at least their sophomore year of studies. The longitudinal nature of the study required at least two years of college work for each student included. In all, the analysis is of 54 individual student transcripts.

Since inception of the SEECS program, four classes of students, specifically students entering into college between fall 2009 and fall 2012, have had the opportunity to participate for an entire four-year cycle. Hence, a pool of 31 students is defined and is called the four-year (4Y) group. Of the 4Y group, six lost scholarship eligibility due to low GPA. Another eight either transferred from

Gannon or switched to a non-SEECS-eligible major. Two students left the program in good standing, due to loss of financial need.

Transcripts of 4Y students, omitting those students who transferred or changed major, were reviewed. The analysis was done seeking to determine whether specific courses ought to be targeted for additional tutoring assistance as a means of supporting students to maintain scholarship eligibility. Based upon anecdotal experience, Calculus and Physics were hypothesized to be "stones in the road" hindering the students' smooth progression to graduation. Connected to the hypothesis was the conventional thinking that for engineering majors, at least, calculus and physics understanding underpins all other technical courses. Thus, failure to thrive in major-specific courses might be tied to failure to grasp the basics presented in calculus and physics. This inference conforms to the results published in [6, 7], as reported in [1].

The results of the analysis support the hypothesis. For the analysis, "low grade" is defined to mean "below B." [Note: prior to fall 2013, Gannon did not issue "minus" grades to undergraduate students.] Of the six 4Y students who were separated from SEECS due to GPA, one had a low grade in the first calculus class, three had low grades in their first physics class, and two had low grades in both (refer to Table 1). Of the 17 remaining non-separated students, four (23.5%) had low grades in either the first calculus or first physics course. Specifically, three received low physics grades (17.6%), one received a low first calculus course grade (5.9%); none received low grades in both courses.

Table 1. Students receiving C+ or lower grades in identified courses, and dismissal rates

	Calculus only	**Physics only**	**Calculus and Physics**	**Neither**
All 4Y students	2	6	2	13
Separated 4Y students	1 (50%)	3 (50%)	2 (100%)	0 (0%)

Viewed from the reverse perspective, of 23 4Y students (omitting 8 transferees) eight had low grades in calculus OR physics, of whom four (50%) were ultimately dismissed. 100% of students receiving low calculus AND physics grades were ultimately dismissed (see Table 1).

Among students admitted to SEECS after completion of their first calculus and physics courses, low grades in those courses did not correlate to dismissal from the program. A plausible explanation of this lack of correlation can be proposed: These students were admitted based upon college-GPA which was sufficiently high to warrant entry after the roadblock courses had already been cleared. None of these students was separated from SEECS due to low GPA. Thus, a correlation appears to exist between "success" in the initial math/physics course(s) and success in maintaining an overall high GPA as required for SEECS membership.

Interventions

Within SEECS currently are several active students who have performed poorly in calculus or physics or both. Many of these students now have a GPA which is either below 3.0, thus putting them into a one-semester probationary period, or have a GPA low enough to threaten probation may be imminent. Inasmuch as SEECS exists for the purpose of increasing retention and fostering students to graduation in STEM, an intervention program has been proposed and partially implemented. The intervention program consists of three intervention approaches: (1) faculty mentoring, (2) a university initiative derived from Supplemental Instruction, STEM-PASS (an acronym for **STEM P**eer **A**ssisted **S**tudy **S**cheme), and (3) student-to-student tutoring.

A. Faculty Mentoring Intervention Approach

SEECS faculty members are diligent about checking the grades and progress of SEECS students. Each SEECS student is assigned one SEECS Principal Investigator (PI) as a secondary academic advisor. Grades are checked at midterm and more frequently as required. When a student is found to be in need of specific intervention, the first line of action is a meeting with their SEECS PI. Students are made aware of the danger of loss of scholarship funding, and the PI and student agree to a plan of action. Students are made aware of existing university resources available to support the goal to improve grades, and may be put in touch with personal tutors. Following creation of this plan, PIs will directly communicate with course instructors to monitor student progress in trouble courses as the courses are proceeding.

B. STEM-PASS Intervention Approach

Gannon University has a newly-implemented university-wide student support service known as STEM-PASS [8]. The program provides peer-assisted student support in selected STEM course sections through extra-help recitations. Students enrolled in these sections may be required to attend a minimum number of STEM-PASS sessions each semester to fulfill course requirements; how participation affects student grade is at the discretion of the facilitating faculty member. Upperclassmen who have successfully mastered the course act as paid STEM-PASS tutors; primary responsibilities include sitting in on a designated course section, running extra-help sessions (generally three per week), and preparing for these sessions, including communication with the faculty member, attention to the course web page on the learning management system, and awareness of the course calendar.

SEECS has adopted the use of the STEM-PASS initiative for the identified roadblock courses. In order to ensure SEECS students are able to register for the appropriate sections, SEECS is providing funding for one tutor in each roadblock course. In exchange, SEECS students are given priority for registration into a STEM-PASS section. This arrangement is a new initiative from the perspective of SEECS, so no data is as yet available for assessment of effectiveness within the SEECS program. Incoming SEECS freshmen will be enrolled in a STEM-PASS section of calculus. SEECS students will also be enrolled in a STEM-PASS section of Physics 111. Students who are seen to be struggling based upon end-of-semester grades will be required to sign up for STEM-PASS sections (if available) for subsequent courses in the same discipline. For example, students struggling at the end of Calculus 1, will be required to sign up for a STEM-PASS section of Calculus 2.

STEM-PASS has operated for three full semesters: Fall 2015 through Fall 2016. Table 2 shows the courses and sections for which STEM-PASS was offered each semester. The total enrollment of these course sections was 378 students in Fall 2015, 555 in Spring 2016, and 588 in Fall 2016. While data is necessarily limited based on only three semesters, quality of final course grades was positively correlated to the number of STEM-PASS sessions attended overall, and similarly, the drop/fail/withdrawal (D-F-X) rate was negatively correlated overall, as shown in Figures 1 and 2, respectively.

Table 2. STEM-PASS Courses

Term	Course Name & Number	# of Sections
Fall 2015	Macroeconomics (BCOR_111) Faculty A	1
	Macroeconomics (BCOR_111) Faculty B	2
	Microeconomics (BCOR_112)	2
	Introductory Microbiology (BIOL_106)	2
	General Chemistry 1 (CHEM_111)	1
	Organic Chemistry 1 (CHEM_221)	2
	Calculus 1 (MATH_140) Faculty A	**2**
	Calculus 1 (MATH_140) Faculty B	**2**
	Physics 1 (PHYS_105) Faculty A	1
	Physics 1 (PHYS_105) Faculty B	1
Spring 2016	Macroeconomics (BCOR_111)	2
	Microeconomics (BCOR_112)	3
	Introductory Microbiology (BIOL_106)	1
	Chemistry of Life 2 (CHEM_106)	3
	General Chemistry 1 (CHEM_111)	1
	Organic Chemistry 2 (CHEM_224)	3
	Fund. of Mathematics (MATH_105)	1
	College Algebra (MATH_111)	2
	Calculus 1 (MATH_140)	2
	Physics for Life Sciences (PHYS_101)	2
	Physics 1 (PHYS_111) Faculty A	**1**
	Physics 1 (PHYS_111) Faculty B	**1**
Fall 2016	Introductory Microbiology (BIOL_106)	2
	Chemistry of Life 1 (CHEM_103)	2
	Physiological Chemistry (CHEM_105)	3
	General Chemistry 1 (CHEM_111)	2
	Organic Chemistry 1 (CHEM_221)	1
	College Algebra (MATH_111_02)	1
	College Algebra (MATH_111_03)	1
	Calculus 1 (MATH_140)	**2**
	Calculus 2 (MATH_141)	2
	Physics 1 (PHYS_105)	2
	Physics 1 (PHYS_111)	**1**

Figures 1 and 2 aggregate data from all STEM-PASS courses across all three semesters, except for CHEM_111 (Fall 2016) for which attendance records are not available. In Figure 1, grade is calculated on a traditional 4.0 scale. In both Figures 1 and 2, the horizontal axis is the number of hours spent at STEM-PASS sessions, and the size of the red circle is scaled to the number of students using STEM-PASS for each number of hours. This number is also shown next to the circles.

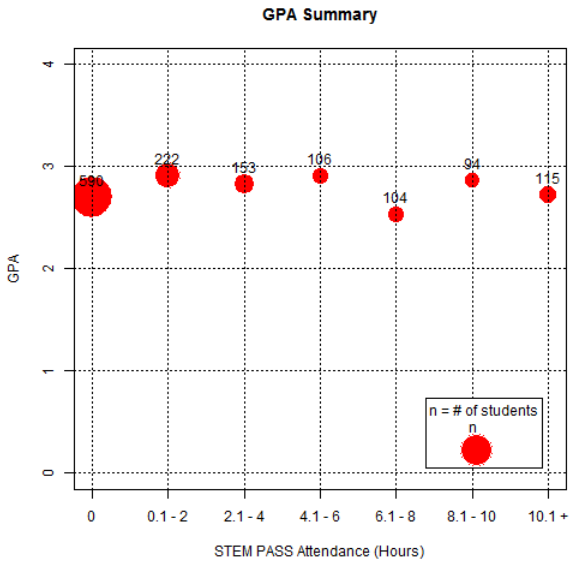

Fig. 1. Average GPA per STEM-PASS attendance

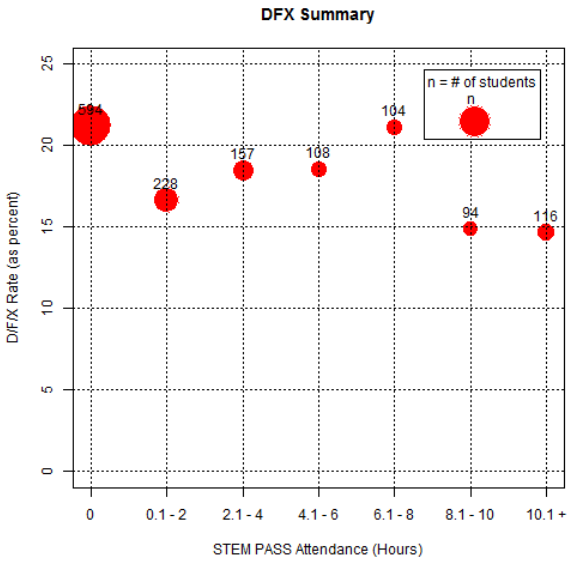

Fig. 2. Average D-F-X rate per STEM-PASS attendance

Table 3 exhibits overall reductions in D-F-X rate compared to the same faculty member's STEM-PASS course D-F-X rate when taught the previous year, comparing fall to fall and spring to spring, highlighting results that further support STEM-PASS's success. Note, this comparison cannot be made for all STEM-PASS courses, due to variations in faculty teaching assignments. STEM-PASS has also made a strong contribution with efforts to assist students to persist at the university through to graduation. While the tabulated courses do not include identified SEECS roadblock courses, the data supports the hypothesis that STEM-PASS can be an effective tool for SEECS retention.

Table 3: Differences in D-F-X rates for STEM-PASS courses when taught by same faculty member in previous year, current academic year 2015-2016

	Fall 2014	**Fall 2015**	**Difference**	**Percent Change**
Macroeconomics (BCOR_111) Faculty A	12.0%	13.3%	1.3%	10.8%
Macroeconomics (BCOR_111) Faculty B	33.3%	32.0%	-1.3%	-3.9%
Microeconomics (BCOR_112)	13.0%	18.4%	5.4%	41.5%
General Chemistry 1 (CHEM_111)	20.0%	17.6%	-2.4%	-12.0%
Physics 1 (PHYS_105) Faculty A	8.1%	0.0%	-8.1%	-100.0%
	Spring 2015	**Spring 2016**	**Difference**	**Percent Change**
Macroeconomics (BCOR_111)	19.0%	9.4%	-9.6%	-50.5%
Chemistry of Life 2 (CHEM_106)	16.2%	8.1%	-8.1%	-50.0%
Fundamentals of Mathematics (MATH_105)	46.2%	33.3%	-12.9%	-27.9%
College Algebra (MATH_111)	19.7%	18.0%	-1.7%	-8.6%
Physics for Life Sciences (PHYS_101)	15.2%	4.9%	-10.3%	-67.8%
Average	**20.3%**	**15.5%**	**-4.8%**	**-23.5%**
Average without Economics (used seldomly)	**20.9%**	**13.7%**	**-5.4%**	**-34.7%**

Figure 3 shows the fall-to-fall retention rate of the 299 freshmen with access to STEM-PASS in the 2015-2016 academic year. Retention rate was positively correlated to time spent at STEM-PASS.

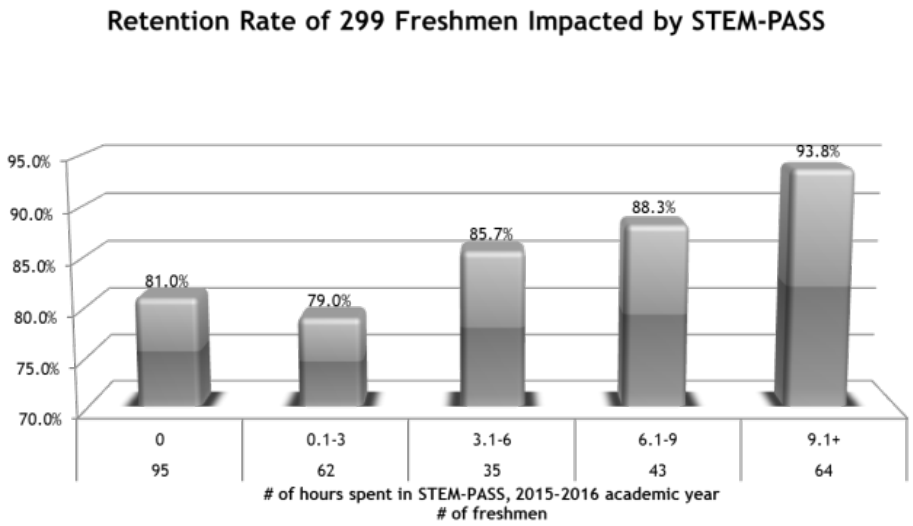

Fig. 3. Freshman retention rates per levels of STEM-PASS participation, academic year 2015-2016

Further, the selection of this intervention strategy for SEECS students struggling with the identified "stones in the road" courses is supported by the results of an internal research study conducted in fall 2014 at the university by the Math Center [9], now subsumed within the STEM Center, which also operates STEM-PASS. Students taking Calculus 1 who were evaluated included the SEECS class..

The first part of the study investigated the correlation between high school GPA vs. final course grade, and best SAT math score vs. final course grade for Calculus 1 students. The study focused on D, F and X (withdrawn) grades (D-F-X). Overall, both correlations were very strong (*r* value of -0.977 for the D-F-X% as a function of the median high school GPA (refer to Figure 4) and *r* value of -0.949 for the D-F-X% as a function of the median best SAT math score). It was observed that, for students who took Calculus 1, the high school GPA was a better predictor of a student's final course grade than the best SAT math score. This supports the results presented in Vernaza et al. [5] where high school GPA was found to be a better predictor of success in the SEECS program. The high school GPA/SAT correlations with Calculus 1 final grade provide the baseline data for a student's expected performance.

The second part of the study looked at the effect of Math Center visits upon Calculus 1 students who made Math Center appointments and the D-F-X% for these students. Several observations were drawn but the one supporting the adoption of this strategy for SEECS follows: for students who spent 5 to 10 hours in the Math Center and whose high school GPA fell between 3.300 and 3.999 (SEECS students fall in this range) or whose best SAT math score was between 520 and

590, the Math Center appeared to have a significant effect on their performance in Calculus 1. In each case, the D-F-X% decreased by more than 20%. This study conclusion bolsters the hypothesis that STEM-PASS can be an effective tool for increasing SEECS retention.

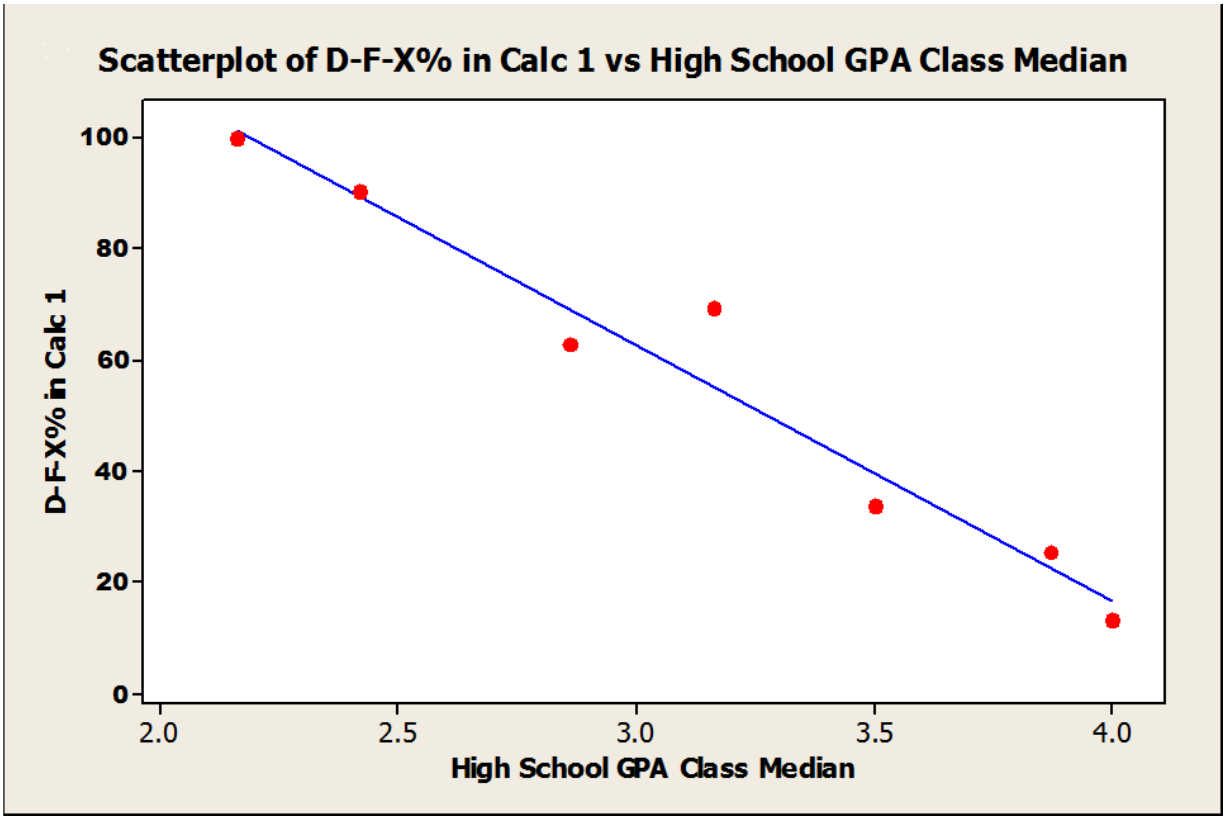

Fig. 4. Percentage of D-F-X Grades as a Function of High School GPA

C. *Student-to-Student Tutoring Intervention Approach*

A final intervention strategy has been informally adopted within SEECS, wherein upper class students who have successfully mastered the material of the identified roadblock courses are recruited, as part of the community effort, to provide tutoring to other SEECS students currently struggling in those courses. Commencing in fall of 2017, this tutoring arrangement will be formalized.

Since the inception of the SEECS project, peer-to-peer mentoring has been a key component. The mentoring focused on the processes of engineering design, and has been structured so that senior students mentor freshmen in project definition and juniors mentor sophomores in project embodiment and execution. The arrangement will be altered so that a portion of upper class students' required time on SEECS activities will be allocated to providing academic assistance to lower-level students. Students seen to be struggling in calculus or physics will be directed to junior or senior assistants, and other students will be encouraged to seek assistance at their discretion.

Note that while peer-to-peer mentoring specifically addresses the issue of attrition due to poor understanding of fundamental courses, it may also address attrition due to "inhospitable environment," or "lack of self-efficacy/self confidence." The design focus is meant to assuage the problem of attrition due to "lack of interest" (see [1]).

Future Steps: Planned Assessments of Intervention Results

The SEECS effort has identified a lack of fundamental understanding of core engineering courses as a primary attrition factor. In this paper, data has been presented to display a correlation between low grades in calculus and physics and low GPA The SEECS program already incorporates numerous features to reduce attrition; one additional strategy will leverage identified university initiatives, especially peer-to-peer mentoring.

Effectiveness of the newly-implemented initiatives (utilizing STEM-PASS, supplemented by in-house tutoring by SEECS students) will be assessed as data becomes available. Assessments will be made based upon the number of SEECS students getting B or better grades in calculus and physics, and comparing overall GPA of students to similar students of previous years (that is, freshmen to previous freshmen, Mechanical Engineering (ME) students to previous ME students, etc.) It is expected that a successful intervention strategy will result in notably higher GPA in comparison to previous similar students.

Overall loss rate of scholars (losses due to GPA, only) will also be assessed for evidence of successful interventions.

Acknowledgment

This work is supported by the National Science Foundation Award under Grant No. 1153250. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

[1] Geisinger, Brandi N. and Raman, D. R., "Why They Leave: Understanding Student Attrition from Engineering Majors," *International Journal of Engineering Education* (1993): 29 (4), 914–925.

[2] Chen, Xianglei and Soldner, Matthew, "STEM Attrition: College Students' Paths Into and Out of STEM Fields," National Center For Education Statistics, U.S. Department of Education (2013). Accessed January March 17, 2016, https://nces.ed.gov/pubs2014/2014001rev.pdf .

[3] Vernaza, Karinna M., Vitolo, Theresa M., Steinbrink, Scott, and Brinkman, Barry J. "Scholars of Excellence in Engineering and Computer Science Phase I: Development and Implementation." Paper

presented at the American Society for Engineering Education Annual Conference, Vancouver, British Columbia, Canada, June 26-29, 2011.

[4] National Collegiate Honors Council, "Basic Characteristics of a Fully-Developed Honors Program." Accessed March 2017, http://www.nchchonors.org/uploaded/NCHC_FILES/PDFs/Basic_Characteristics_-_Program.pdf .

[5] Vernaza, K.M., Steinbrink, S.E., Brinkman, B.J. and Vitolo, T.M. "Scholars of Excellence in Engineering and Computer Science Program, and NSF-Funded S-STEM Grant: Assessment and Lessons Learned – First Award." Paper presented at the International Conference on Engineering Education and Research, Hamilton, Ontario, Canada, August 24-26, 2014.

[6] Good, Jennifer, Halpin, Glennelle, and Halpin, Gerald, "Retaining black students in engineering: Do minority programs have a longitudinal impact?" *Journal of College Student Retention* (2002): 3(4), 351–364.

[7] Webster, Thomas J. and Dee, Kay C., "Supplemental instruction integrated into an introductory engineering course," *Journal of Engineering Education* (1998): 87(4), 377–383.

[8] Nogaj, Adam and Kons, Elizabeth. "Beyond Tutoring: Intrusive Academic Assistance to Increase Student Success and Retention." Paper presented at the 12th Annual National Symposium of Student Retention, Norfolk, Virginia, October 31-November 3, 2016.

[9] Nogaj, Adam. "High School GPA and SAT Scores as a Predictor of Success in STEM Studies, and Assessment of STEM-PASS Initiative at Gannon University," unpublished internal document, Gannon University, Erie, PA, 2015.