# A study of the effects of peer tutoring in relation to student GPA

**Dr. Scott Steinbrink, Gannon University**

Dr. Scott Steinbrink is an associate professor of Mechanical Engineering, primarily tasked with teaching computer methods and design.

**Mr. Adam Finn Nogaj**
**Dr. Karinna M Vernaza, Gannon University**

Dr. Karinna Vernaza joined Gannon University in 2003, and she is the Dean of the College of Engineering and Business and a Professor in the Mechanical Engineering Department. She earned her Ph.D. and M.S. in mechanical engineering from the University of Notre Dame. Her B.S. is in Marine Systems Engineering from the U.S. Merchant Marine Academy. 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. Dr. Vernaza does research in engineering education (active learning techniques) and high-strain deformation of materials. She is currently the PI of an NSF S-STEM. She has served in the North Central Section Board since 2013.

**Dr. Lin Zhao, Gannon University**

Lin Zhao received the Ph.D. degree in electrical engineering from the University of Western Ontario, London, ON, Canada in 2006. She received the B.Sc. and M.Sc. degrees in electrical engineering from Shandong University, Jinan, China, in 1993 and 1996 respectively. From 1996 to 2002, she was a Faculty Member with the School of Control Science and Engineering and the School of Electrical Engineering, Shandong University. From 2002 to 2007, she was first a Research and Teaching Assistant and then a Postdoctoral Fellow with the Applied Electrostatic Research Center, the University of Western Ontario. Since 2007, she has been with the Department of Electrical and Computer Engineering, Gannon University, Erie, PA, where she is currently a Professor. Her research interests include electrical machinery design, modeling and analysis of electric drives, and control of electric drives.

**Dr. Saeed Tiari, Gannon University**

# Work-In-Progress: A study of the effects of peer tutoring in relation to student GPA

Scott Steinbrink, Adam Nogaj, Saeed Tiari, Lin Zhao, Karinna Vernaza

**Abstract**

In the fall of 2015, Gannon University implemented a semi-mandatory peer-to-peer tutoring program within a variety of courses that have traditionally been linked to high student attrition. Some of these courses have previously been identified as critical for success in the NSF S-STEM grant in effect at the university, and thus it is of interest to determine whether students in the S-STEM program would benefit from inclusion in the peer-tutoring program. The peer-tutoring program presents a naturally occurring experiment because some sections of these courses have included the peer-to-peer tutoring program, while others have been traditionally taught without this tutoring aspect. As a result, the authors have been able to begin to assess the effectiveness of this tutoring on student performance specifically in Calculus I, Calculus II and the lowest-level Calculus-based Physics course. This study groups students by GPA at the beginning of the semester (less than 1.0, up to 1.5, up to 2.0, up to 2.5, up to 3.0, up to 3.5 and above 3.5) and within those groups gathers data on final course grade and GPA for each student at the conclusion of the semester. Comparison is made between average performance of students enrolled in peer-tutored and in traditionally-taught sections. While the results are quite preliminary, it is possible to begin to estimate (1) whether student performance in the class (as measured by final grade in the course) is affected by the tutoring, and (2) which student group or class is most strongly affected by the tutoring. Inasmuch as there are confounding variables (such as different instructors among sections and differing levels of student motivation) that have not yet been controlled, this study is submitted as a work-in-progress. While it is not a new insight to say that tutoring helps struggling but motivated students (previous studies have indicated that this peer-to-peer mentoring program has had a good effect on student success, by reducing the percentage of students receiving a final grade of D or F or withdrawing from the course for students enrolled in peer-tutored sections) the longer-term goal of this study is to determine the effectiveness of tutoring for nominally higher-performing students.

**Background**

The Scholars of Excellence in Engineering and Computing Sciences (SEECS) program was inititated in the fall of 2008, through a National Science Foundation grant under the Scholarships in Science, Technology, Engineering and Mathematics (S-STEM) program. The program has since been maintained through two more S-STEM grants (NSF DUE Awards 0806735, 1153250, 1643869). The goal of the S-STEM program is to provide financial assistance to qualified students for the purpose of incentivizing domestic production of a robust STEM workforce. The SEECS implementation of that grant program provides scholarships to selected undergraduate students of engineering and computing sciences at Gannon University. Students are recruited as incoming freshmen, and are eligible for retention in the SEECS program so long as program requirements are met, including maintenance of a minimum 3.0 GPA. As the grant activity has proceeded, it has been noted that students who fail to achieve a grade of “B” or better in Calculus I, Calculus II or Physics 1 have typically failed to maintain an overall 3.0 GPA as well. There is thus an interest for SEECS in providing additional academic assistance to our students in support of GPA maintenance, leading to better employment and/or graduate school opportunities, as well as continued financial assistance.

Of interest to the investigators is the assessment of (1) the effect of academic interventions on retention rate of all STEM students at the university, and (2) specific effect on retention among SEECS scholars – a high-performing set of engineering and computer sciences students. The specific research question is: **"Does peer-assisted study have a measurable positive effect on academic performance for nominally high-achieving students?"** One program that is being investigated as a possible intervention is a form of Supplemental Instruction (SI) that involves peer mentoring. This study looks at how that program might be affecting SEECS students.

According to Arendale [1], SI was created at the University of Missouri-Kansas City (UMKC) in 1973 as a mechanism to attempt to improve student performance in historically difficult courses in order to improve grades, reduce withdraw rates, and support persistence toward graduation. By focusing on high-risk courses as opposed to high-risk students, it aimed to avoid a remedial stigma. The UMKC design called for an SI leader (a student or staff member deemed competent to support the target course) to attend all target course lectures and in turn, facilitate at least three hours per week of extra-help group-based recitations. At such sessions, SI leaders aimed to maximize active student involvement with the applicable material, but did not serve as substitutes for professors or reteach lessons from scratch. All students in the target class sections were encouraged to attend, but there was no attendance requirement or extrinsic incentive.

STEM-PASS (the preferred-use acronym for Science, Technology, Engineering & Mathematics Peer Assisted Study Scheme) began in fall 2015 at Gannon University, as a derivation from SI. Undergraduate students who have taken and excelled at the historically-difficult target course, or who have taken and excelled at one or more similar courses were selected and hired as STEM-PASS tutors for the target courses. With few exceptions, each tutor sat in on all meetings of one section of a target course, in turn offering three one-hour extra-help recitations to students of all sections of the target course taught by the same instructor, regardless of section. (At Gannon, it was common for instructors to teach one, two, or three sections of the same course. The tutor would work with students from all STEM-PASS sections taught by a common instructor.) Additionally, the tutor was responsible for preparing session material and communicating with the instructor as needed.

Unlike SI as defined by Arendale [1], some instructors of STEM-PASS courses counted attendance in some way toward course grade, such as by being worth a portion of course grade, or as extra credit, either on assessments or directly toward the final course grade. When attendance has been required or incentivized, instructors generally created parallel means of earning points for students who could not attend sessions as scheduled due to other courses, responsibilities, or life circumstances.

The name STEM-PASS was chosen to both differentiate from SI based on the fact that not all tenets of UMKC's SI were not going to be included in its overall implementation, and to choose a name with less generic implications, as many activities could be said to "supplement instruction."

## Academic Intervention Literature Review

While there exist many published studies discussing the effectiveness of SI programs, it is not necessarily straightforward to rigorously compare results or draw overarching conclusions. Dawson, van der Meer, Skalicky, and Cowley [2] performed a literature review of SI articles published between 2001 and 2010, with an initial study in mind to perform a quantitative meta-analysis of findings. However, as a result of "methodological heterogeneity, poor method quality, and insufficient description of method" and lack of actual quantitative focus in articles, they were only able to compile a qualitative meta-analysis. They noted additional complications, primarily inconsistency of what SI actually entails and differing standards pertaining to student eligibility, session attendance, definitions of participation, and which courses were covered. In many articles, such qualities were not actually discussed, making it impossible to compare findings between articles on an equal level. In addition to students' final course grades, other examples of dependent variables were overall course completion rates and per-course changes in overall average, student performance in later courses, and general student satisfaction. Ultimately, the researchers agreed that their review of the literature was indeed consistent with the prevailing narrative in the literature base that SI has benefitted students. However, a slew of methodological issues created room for doubt in their conclusions; failure to report statistical significance levels and effect size was rampant, many study designs were incomplete, and there existed reasonable potential for publication bias in that authors may only have been publishing their institutions SI results when they painted activities in a positive light.

Inasmuch as most SI programs have a baseline purpose of supporting at-risk students to success, there has not been much written about the effect of SI on nominally higher-performing students.

## Data Collected

Previous observations by these authors [3] have indicated that there are several "Roadblock" courses in the engineering curriculum in which student attainment of a grade of less than "B" correlates to eventual accumulation of a GPA below 3.0. Three of these courses have been specifically identified for this study: Calculus I, Calculus II and Physics 1 (calculus-based mechanics). These courses have been offered with the STEM-PASS option. In this analysis, a comparison is made between final grades of students in STEM-PASS sections and final grades of students in traditionally-taught ("traditional," non-STEM-PASS) sections.

Data was gathered by the university office of Institutional Research and Assessment for all students enrolled in one or more of these courses beginning in the fall semester of 2015 and through the spring semester of 2019. Collected data relevant to this study includes:

- Enrollment in all sections of MATH140 (Calculus I), MATH141 (Calculus II) and PHYS111/PHYS210 (Fundamentals of Physics 1 – a course number change was made during the study period) by semester;
- University GPA of all students enrolled in all sections, at the beginning of the semester;
- High school GPA for those same students;
- Final grade awarded for all students enrolled in all sections;
- STEM-PASS status of each section

The raw data was edited prior to analysis in the following ways.

1. All entries were deleted for students who officially withdrew from the course, as indicated by "X" grade. Previous institutional research has indicated that STEM-PASS has positive impact on reduction of D-F-X rates [4] however for this study only students completing the course are appropriate for inclusion.
2. Entries were deleted for students with no known GPA entering the semester. This second deletion is justified on the basis that we wish to know whether STEM-PASS might be more effective for one student group than for another, specifically grouping by incoming GPA. Thus for purposes of this study, students without known GPA entering the semester were deemed to be inappropriate for inclusion. This exclusion forced the omission of new transfer students. In order to have a pool for comparison for Calculus I, typically taken by first-semester freshmen, high school GPA was used if no university GPA was available. Some students were thus omitted from the study as well, due to unknown high school GPA.
3. Letter grades were converted to numeric grades, per Table 1:

**Table 1: Letter to Numeric Grade Conversions**

| Letter Grade | Numeric Value |
|---|---|
| A or A+ | 4.0 |
| A- | 3.7 |
| B+ | 3.3 |
| B | 3.0 |
| B- | 2.7 |
| C+ | 2.3 |
| C | 2.0 |
| C- | 1.7 |
| D | 1.0 |
| F | 0.0 |

In total, 1357 entries were analyzed for this study, distributed per Table 2, below.

**Table 2: Student records analyzed**

| | **Calculus I** | **Calculus II** | **Physics 1** |
|---|---|---|---|
| Traditional sections | 394 | 310 | 117 |
| STEM-PASS sections | 147 | 144 | 245 |
| **Total** | 541 | 454 | 362 |

**Analysis of Student Performance Data**

Chronologically, the first analysis performed on the data was the analysis of final grade versus entering GPA, for all included students. The results are included in Table 3.

**Table 3: Average Final Grade for Selected Courses, Sorted by GPA**

| Incoming GPA | Calculus I (STEM-PASS) | Calculus I (traditional) | Calculus II (STEM-PASS) | Calculus II (traditional) | Physics 1 (STEM-PASS) | Physics 1 (traditional) |
|---|---|---|---|---|---|---|
| > 3.5 | 2.628 (n=87) | 3.041 (n=190) | 3.281 (n=75) | 3.238 (n=133) | 3.167 (n=106) | 2.981 (n=32) |
| > 3.0; <= 3.5 | 1.764 (n=39) | 2.113 (n=104) | 2.275 (n=32) | 2.218 (n=84) | 2.053 (n=74) | 2.231 (n=29) |
| > 2.5; <= 3.0 | 1.064 (n=11) | 1.665 (n=48) | 1.014 (n=22) | 1.742 (n=43) | 1.381 (n=32) | 1.723 (n=39) |
| > 2.0; <= 2.5 | 1.500 (n=4) | 1.081 (n=27) | 0.500 (n=8) | 1.256 (n=36) | 1.104 (n=25) | 1.387 (n=15) |
| > 1.5; <= 2.0 | 0.9 (n=3) | 0.793 (n=14) | 0.617 (n=6) | 1.333 (n=10) | 1.342 (n=7) | 3.3 (n=1) |
| > 1.0; <= 1.5 | 0.5 (n=2) | 1.100 (n=7) | 0.000 (n=1) | 0.667 (n=3) | N/A | 0.000 (n=1) |
| <= 1.0 | 1.7 (n=1) | 0.000 (n=4) | N/A | 0.000 (n=1) | 0.000 (n=1) | N/A |
| Total | 147 | 394 | 144 | 310 | 245 | 117 |

Because there are few students in the lowest GPA categories, comparison is not attempted for those students. Meaningful comparisons would seem to be possible for students with GPA higher than 3.0 going into Calculus I, GPA higher than 2.5 going into Calculus II and for GPA higher than 2.0 going into Physics 1. The apparent trend is for a lower grade to be earned in the STEM-PASS sections: of the 9 possible comparisons, STEM-PASS students earned a higher average grade in just one case, and noticeably lower grades than their traditionally-taught counterparts in 6 cases. This is a surprising result, and requires further investigation. Note, however, that while the learning objectives and textbook were the same for all sections of each course, the instructors were not the same. Some professors adopted STEM-PASS for all of their sections, while others chose not to participate. It is thus quite possible that the differences we see in student outcomes is merely an effect of different instructors. This of course needs to be investigated in depth as this work-in-progress proceeds.

It is possible that the lower GPA in STEM-PASS sections might not be related to teaching methodology or instructor at all. It may be instead that the students themselves are the causal factor in the grade differences, as one might expect previous success to be a predictor of current success. To investigate this possibility, another overall comparison was made. Table 4 shows the average GPA and its standard deviation of all students entering into the target courses, separated by STEM-PASS and traditional sections, along with average final grade and its deviation.

**Table 4: Aggregate Data – Entering GPA and Final Grade for all Students**

| | Entering GPA mean | Entering GPA standard deviation | Final Grade mean | Final Grade standard deviation |
|---|---|---|---|---|
| **Calculus I STEM-PASS (n = 147)** | 3.503 | 0.603 | 2.181 | 1.315 |
| **Calculus I traditional (n = 394)** | 3.316 | 0.723 | 2.349 | 1.377 |
| **Calculus II STEM-PASS (n = 144)** | 3.249 | 0.633 | 2.422 | 1.280 |
| **Calculus II traditional (n = 310)** | 3.354 | 0.641 | 2.434 | 1.333 |
| **Physics 1 STEM-PASS (n = 245)** | 3.077 | 0.572 | 2.149 | 1.120 |
| **Physics 1 traditional (n = 117)** | 3.285 | 0.590 | 2.322 | 1.296 |

Taken on its own, the data of Table 4 is inconclusive for Calculus II and for Physics 1. Each of these courses show the expected trend: somewhat higher GPA going into the semester corresponds to somewhat higher course grade for Physics 1 and approximately the same GPA in leads to approximately the same grade out for Calculus II. The data of Calculus I tells a different tale.

For Calculus I, STEM-PASS students entered with a notably higher GPA, and exited with a notably lower course grade, relative to their traditionally-taught student counterparts. This is an interesting and somewhat disturbing note, but there are two important things to remember, before adopting any conclusions.

- As previously mentioned, no accounting has been made yet of the effect of differing instructor. Compared to each other, different instructors are likely more or less effective at encouraging student learning, and different instructors may be more or less strict graders. As a consideration in furtherance of this point, we note that Calculus I is taken by more students than Calculus II, necessitating more instructors, and our Physics department is a small one with few instructor choices. Thus the effect of instructor, if it is significant, is likely to appear most visibly in the data for Calculus I.
- Second, it should be borne in mind that Calculus I is taken primarily by incoming freshmen, in their first semester of college. A large percentage of these students thus have no college GPA. For students with no university GPA, high school GPA is utilized. It must be considered that the college environment might produce different levels of success in comparison to the high school environment. The use of high school GPA was necessary in order to make comparisons, but its use as a substitute for college GPA might affect the comparisons made.

To provide better clarification whether GPA might be the primary factor in grade difference between STEM-PASS and traditional sections, scatter plots were produced for all courses. These plots are shown in Figure 1 for Calculus I and in Figure 2 for Physics 1. A plot was also made for Calculus II, but because there is no obvious difference between STEM-PASS and traditionally-taught student success for that course, the figure is not included here.

**Figure 1: Final Grade v Entering GPA, Calculus I, omitting spring 2016, section 2**

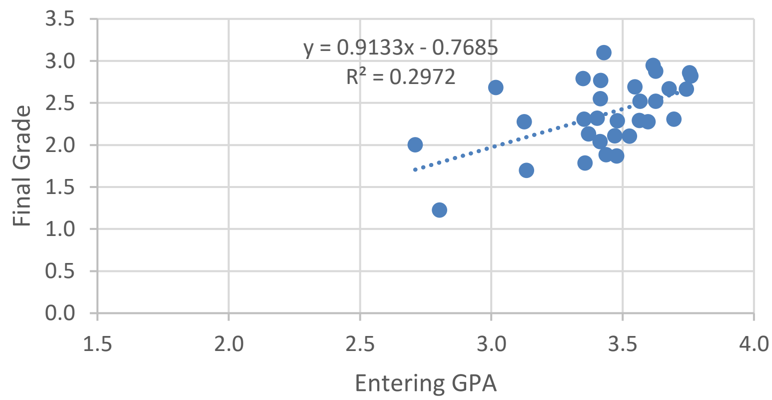
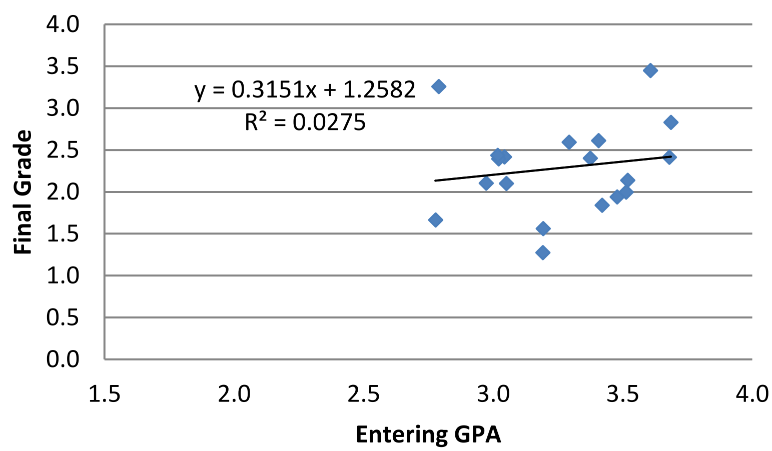



**Figure 2: Final Grade v. Entering GPA, Physics 1**




Data for Figure 1 omits one section, specifically the spring semester of 2016, section 02. That section included 15 students in this study, from which only 4 received passing marks – two "D" grades, one "C," and one "B." Inclusion of this anomalously poor student performance data badly skews the result. The following explanation was offered by the chair of the Mathematics department: the section was a very late-enrolled section, with a majority of students not attending class after the semester started. The instructor was a well-respected and experienced professor, well represented within the overall data pool for this study, and with no history of overly-strict grading. This anomalously-low performing section is thus omitted as seemingly a result of non-serious student participation, and thus presumed to be unrelated to STEM-PASS status of the course.

A trend line has been included for each scatter plot, with $R^2$ values calculated in Excel©. Low correlation value between the axis data points suggests that the supposition that "success breeds success" might not be correct for these courses, though the correlation between GPA and final grade was stronger for Calculus II: $R^2 = 0.471$ for that course. For Calculus I and Physics 1, the most likely contributing factor to course grade would thus seem to be either *instruction* or *instructor*. Bearing in mind that it is not yet possible with the data we have to consider the instructor, the apparent trend (negative effect on student grades) of STEM-PASS must be considered, but cannot be concluded. Investigation of the distribution of grades by instructor is an activity for future work.

**Qualitative student feedback on the interventions**

During the spring 2017 semester, the study site polled all students in STEM-PASS courses about their attitudes toward STEM-PASS. The focus of the survey was primarily assessment of student attitudes about graded or incentivized attendance, but respondents were optionally able to qualitatively share feedback about any aspect of their STEM-PASS experience in a brief written response. 51 written responses were received, from which five themes emerged:

- need for different or additional session times or overall difficulty to make scheduled times (cited by 35.3% of respondents);
- positive experiences or feedback on tutor (27.5%);
- negative experiences or feedback on tutor (13.7%);
- attendance requirement-related comments (37.3%);
- other comments on STEM-PASS structure (7.8%)

(Percent totals do not add up to 100% due to some responses addressing multiple themes.)

In addition to the feedback solicited as described above, students from the current SEECS cohort who were enrolled in STEM-PASS sections were directly contacted to assess their perception of the intervention. These students all fall into the high-performing classification that is the subject of this study. The specific questions asked were:

1. Does STEM-PASS assist you with the academic performance and learning experience in such course(s)?
2. How do you feel about the STEM-PASS? Any suggestions?

Eight scholars were surveyed, five responded. Out of five, one indicated that he "never used STEM-PASS". The following is the feedback received from other four students:

- Student 2: "I have had a few classes where stem pass was offered, and I always found it to be helpful. The extra help from a fellow student is very beneficial. I don't have any suggestions as I have always had a good experience with STEM-PASS!"
- Student 3: "I had STEM PASS for physics 1 and it was a great help to me. It provided help with homework questions I had and really helped me excel in the class. I really like STEM PASS for classes such as physics and calculus etc."

- Student 4: "I think STEM PASS can be helpful and is definitely a convenient resource/option to have. The benefits definitely vary from person to person, but in general, it's just nice to know that it is available. Personally, I didn't use my physics STEM PASS all that much so I don't know how much more in depth I can go, but I definitely think it's a resource that should stick around."
- Student 5: "STEM PASS classes had been extremely helpful in understanding the concepts especially in physics. The tutors understood how to explain it in a simpler way that the students understand sometimes especially while going over the homework. This year I will have a recitation with Thermo, which I feel will be extremely helpful."

The responses from these surveyed students who took advantage of the STEM-PASS sessions were uniformly positive, suggesting that the tutoring was thought to be helpful.

**Conclusions and Future Work**

Analysis of university data available to-date provides ambiguous results. Previously published work has shown that SI programs can have a positive influence on student success, but no clear indication of that success is found in the data for this study. However, there is also no clearly compelling evidence that STEM-PASS is harmful to students. There remain significant unanswered questions about instructors' use of the STEM-PASS resource, as well as a need to control for instructor grading preferences. It may perhaps be safely concluded from the data analyzed that student performance in Calculus I, Calculus II and Physics 1 is not well-predicted by student incoming GPA, thus eliminating one area of uncertainty.

This report documents analysis of a naturally occurring experiment; no controls were in place for the collected data. The lack of controls contributes to the uncertainty of interpretation. The next step will entail creation of a more structured experiment. To that end, efforts will be made to enlist the Mathematics and Physics departments to randomize assignment of STEM-PASS sections among instructors and sections and standardize its implementation. In addition, the following items have been identified as potential avenues for effort:

- For first-semester freshman students entering Calculus I, SAT or ACT mathematics section scores might be used instead of high school GPA as a benchmark of previous success. This might perhaps be a better indicator of mathematical inclination for students entering that course;
- For Calculus I, separation of fall semester results from spring semester results. This would perhaps be useful because the spring semester course is more typically taken by students who either failed Calculus I in the fall or required an Algebra/Trigonometry refresher course first;
- Investigate the effect of instructor on final grades – find a way to normalize grades to control for natural variance grade assignments due to differing instructors.

**Acknowledgment**

This research was supported with funding from the National Science Foundation. 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] Arendale, D. (1997). SI (SI): Review of research concerning the effectiveness of SI from the University of Missouri-Kansas City and other institutions from across the United States.

[2] Dawson, P., van der Meer, J., Skalicky, J., & Cowley, K. (2014). "On the effectiveness of SI: A systematic review of SI and peer-assisted study sessions literature between 2001 and 2010" *Review of Educational Research*, *84* (4), 609–639.

[3] Scott Steinbrink, Karinna M. Vernaza, Barry J. Brinkman, Theresa Vitolo, and Adam Finn Nogaj, "Stones in the Road: Analysis and Response to "Roadblock" Courses in the SEECS Program," *Proceedings of ASEE National Conference*, Columbus, OH, July 2017

[4] 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.