Development of a Method to predict how Successful a Student will be in an Engineering Program

Stephen Hill and Matt Marone
Mercer University School of Engineering and College of Liberal Arts and Sciences

Abstract

The foundations of an undergraduate engineering education are courses in mathematics and physical and natural sciences. So much so that many colleges and universities uses these courses to reduce the total number of students matriculating through their respective programs. But is that really true? Calculus I is typically taught in the first semester of most college freshman programs when students are still developing their skills as university students. Whereas the first course in physics is taught after that first mathematics class has been completed. Which course is more predictive to a successful engineering student? What is discussed here is a method developed to mine the data in the data management system and one method to assess the results of these students. Also provided is a sample of the results of an initial sampling of data from multiple years.

Keywords

Engineering Education, First-Year Students, Student Success

Introduction

First year retention of students in an engineering program is something that has been studied for many years by many different authors. Geisinger and Raman identified six factors from the academic and classroom climate, grades and conceptual understanding, self-efficacy and confidence, high school preparation, career goals, race, and gender (1). They looked at many references from survey to longitudinal data to distinguish between the factors. They found that many of the students who leave engineering schools are often doing well (2, 3, 4) and found many they delve into detail on the six factors listed above. This paper is intended to focus on the academic and classroom climate and more specifically what happens in those first math and science courses that the first-year student will take. The initial impetus for this project developed from Professor Marone's efforts to assess his teaching effectiveness and after discussion with him, this evolved into a broader study of the engineering school. Seymour and Hewitt's book, "Talk about Leaving" goes into detail about many of the reasons STEM students leave their major. They looked at seven campuses over three years and determined 40% of engineering students leave the program (2). The same text cited the reason for leaving school were a lack of faculty guidance, academic support, and personal encouragement to name a few. Sondgeroth and Stough discussed that many students leave due to hostile environments and poor teaching styles (5) within the classroom. This includes when learning styles and teaching styles are not similar. This can be avoided in some cases by taking a different professor, but at smaller schools where often one section is taught by the same lecturer, this becomes problematic.

Furthermore, the students' first recourse of action is to leave the engineering program for a major with lower difficulty in the required foundational coursework (math and physics) or even leave of a program where is it is easy to see a connection between the lower level coursework and their intended field of study early in their academic career (6). The same authors discuss the importance of community with both their peers and the faculty within those programs.

All of these point to a difficult transition of a successful high school student to a college student in a competitive environment. Many find this the first time they have been challenged and must develop study habits (7). Furthermore, the first classes that engineering students will take are either in mathematics or in the sciences. This includes Calculus, Chemistry, and Physics. This paper will look at two of these classes Calculus I and General Physics I and compare the performance in those classes to success in the engineering program.

Student Cohort

This study first mines the data from the student data management system at the university with proper approvals from the Institutional Review Board (IRB). Students' data is taken from the college of liberal arts and sciences (CLAS) at Mercer University and filtered based on the enrollment in the particular courses taken. This data has been made anonymous by removing identifying information such as high school location, gender, and ethnicity can be included. Data captured includes engineering GPA, cumulative GPA, first enrollment status in class, grade in class, and final enrollment status. This data is then sorted in any form to look at student success as well as professor performance in the classroom meaning the D/F/W rate.

The students that were examined for this study were both enrolled in Calculus I and General Physics I at the university over a period from fall 2016 to fall 2020. The school of engineering at this university averages 176 new freshmen into the engineering program on a yearly basis from the period of study; however, many students will transfer dual-enrollment or AP credit during their high school career for these classes. Therefore, the total number of students investigated was 423 students. A larger student population can be analyzed if just Calculus I or and General Physics I is examined individually, but for this study, the interest is in students who took both of these classes.

Table 1. Students' Examined

Active Students	**226**	
Active Not Attending	2	
Graduated	112	
Non Returning	48	
Program Change	22	Non-Engineering
Suspended	13	
Total Students	423	

Table 1 breaks down the distribution of the students last enrollment status as of Fall 2020. Of these students, one hundred and twelve have graduated and two hundred and twenty-six are still active in the program. Forty-eight students have left program and thirteen were suspended due to poor academic performance. These students represent various ethnicities and come from both rural and urban settings mostly in state. Twenty-two students have switched majors from engineering to another major but remained at the university to complete their studies. The students' performance in both and General Physics I and Calculus I is illustrated in Figure 1.

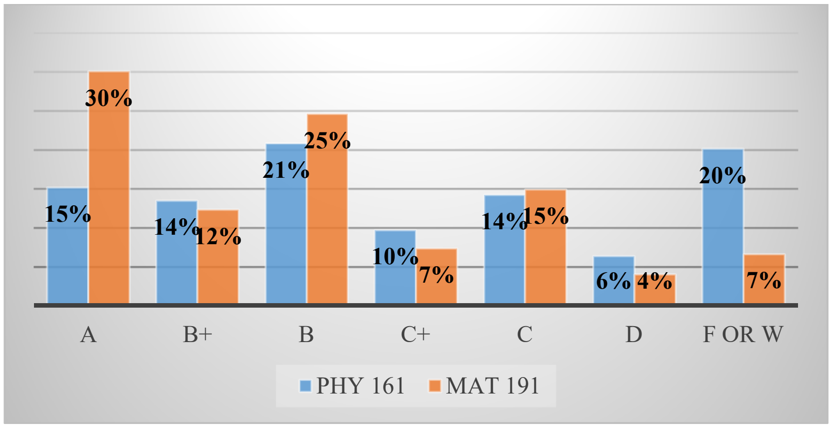

Figure 1. Grade Distribution in Both Classes

From the figure, the students' performance in Calculus was better than the performance in Physics with 89% of students making a grade of C or better and able to move on to the next course. In Physics, the pass rate is 74% of C or better and 80% pass rate if the student did not plan to take Physics II, which is not required for all of the majors. If one were to focus on the students who have graduated, 98% of those students made a C or better for Calculus I and 87% of the students made a C or better in and General Physics I. This leads one to believe that good performance in either of the classes is a predictor of matriculation through the program, but even if the performance is not stellar in and General Physics I, the student still has a chance to graduate. One of the reasons, is that some of the majors do not rely heavily on the material taught in Physics I. Students in Electrical or Computer Engineering rely on the material taught in General Physics II; however, to take that course a grade of C or better must be earned in and General Physics I. The results are encouraging in both classes.

Performance in Calculus I

If the data is further explored and all of the engineering students that have taken Calculus I on campus is analyzed, the grade distribution is shown in Figure 2. The grade S was given during the Spring of 2020 where many colleges and universities implemented modified grading schemes due to the pandemic (8).

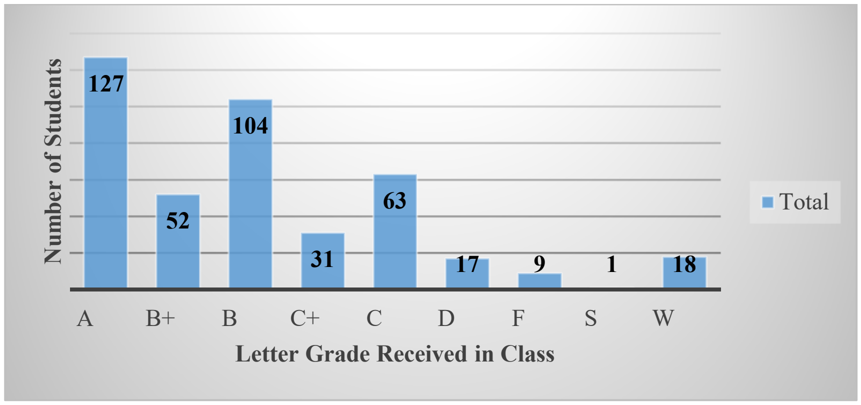

Figure 2. Student Performance in Calculus I from 2016-2020

Since many of these students are still continuing their education here, it is more informative to consider the students who have graduated from the engineering school. This data is shown in Figure 3.

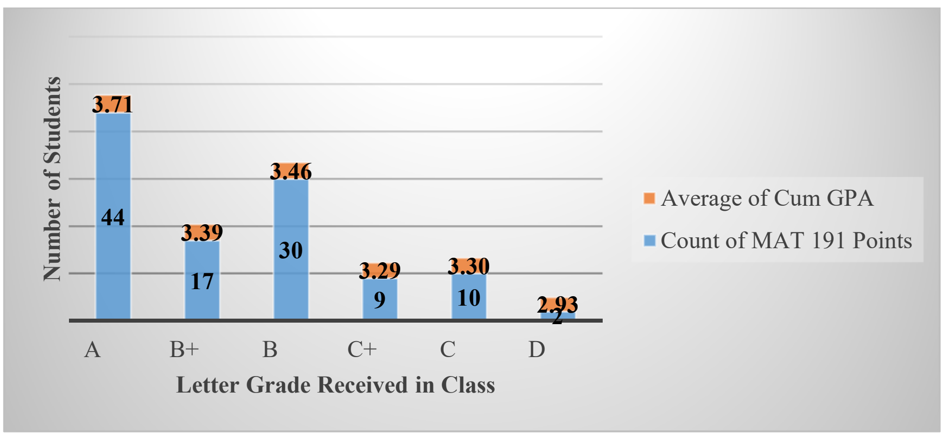

Figure 3. Student Performance in Calculus I from 2016-2020 (Graduates)

Again, one can see that the students who did well in the course maintained a good GPA while at the university. The cumulative GPA is used as it is nearly the same as the engineering GPA for this cohort of students and is shown in Figure 4.

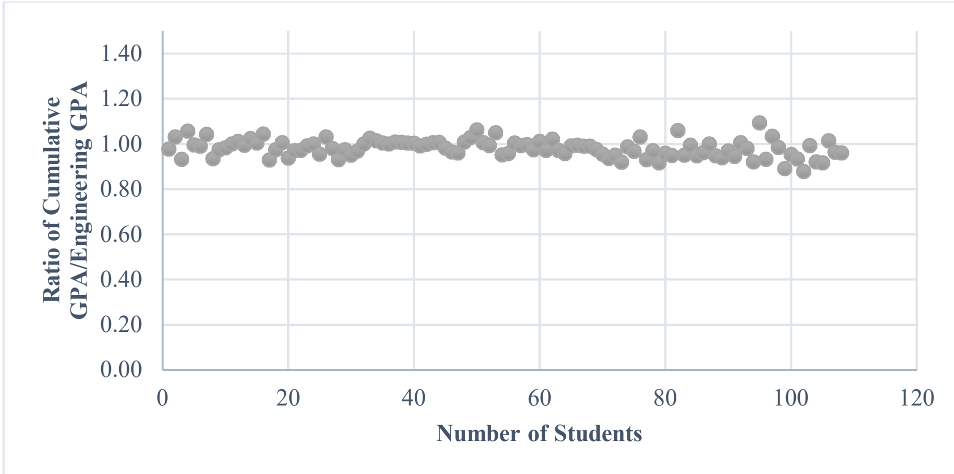

Figure 4. Ratio of the Cumulative GPA to Engineering GPA

The students who made an A in the course graduated with an average GPA of 3.71/4.00 and the ones who passed with a C graduated with a 3.30/4.00 GPA. Furthermore, the two students who had to retake the course due to a grade below a C on the first attempt also graduated with an average cumulative GPA of 2.93/4.00.

Performance in General Physics I

If General Physics I is considered, the grade distribution is shown in Figure 5. The grade of S was given to eighteen students during the Spring of 2020 due to the same explanation as before and one was given a grade of U, which is interpreted as a failing grade.

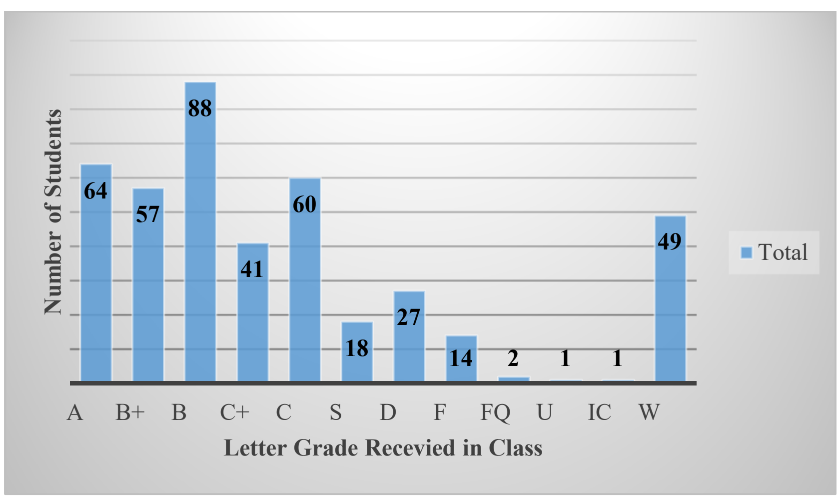

Figure 5. Student Performance in General Physics I from 2016-2020

Fourteen students failed the course with a letter grade of F, two students just stopped coming to class and received the letter grade of FQ, and many have withdrawn from the course. Under further investigation of the withdrawals, the students range from good students with cumulative GPAs greater than 3.8 to students who were later suspended. Therefore, it is difficult to find a trend with those students other than anecdotal discussion upon the actual students who withdrew.

Focusing on the students who have graduated (Figure 6), the same trend is shown as in the Calculus I class. The students who made an A in the course graduated with an average GPA of 3.76 and the ones who passed with a C graduated with a 3.26 GPA. Further, the fifteen students who had a grade of D or withdrew from the course on the first attempt also graduated with an average cumulative GPA of 3.26 and 3.48, respectively.

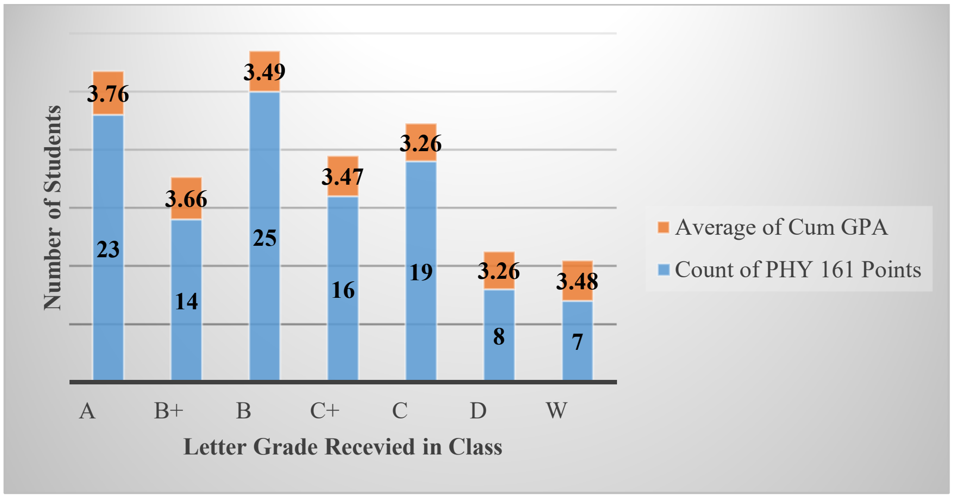

Figure 6. Student Performance in General Physics I from 2016-2020 (Graduates)

Conclusion

From these results, the trends show that students who do well in both Calculus I and General Physics I have a good chance of success in the engineering program. The data also shows that students who do not perform well have a chance to rebound and still graduate with a good GPA if they are resilient during the process. This study needs to be extended to some other anchor classes such as Calculus II, Chemistry I, and Physics II. The classes can be used with the existing classes to look at the major specifically. Meaning, for mechanical engineering students Physics I may be a good predictor and for environmental engineering students maybe Chemistry is a better predictor. At any rate, this method of analysis data is useful in looking at student success.

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Stephen Hill earned his Ph.D. from Georgia Institute of Technology. He is currently an associate dean and associate professor at Mercer University School of Engineering. He worked for Schlumberger Oilfield Services for 14 years before returning to academia in 2013 to pursue his goal of educating the next wave of engineers entering the work force. His experience in the work force was in product development of downhole tools related to the extraction of oil and natural gas from various reservoirs. His current research interests include impact erosion, wear, two phase flow phenomena, solid/liquid phase change, desalination, highly ionized plasma, and engineering education.

Matt Marone earned his Ph.D. in Physics from Clemson University. He is an applied physicist who has taught introductory physics at Mercer for over 20 years. Dr. Marone is also an aerospace consultant and develops novel experimental apparatus. He has one foot in the engineering world and one in the world of physics.