Student Success in Mechanical Engineering: Utilizing Data to Understand Success for Under-represented Groups

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Abstract

For decades, studies have documented the achievement gap for under-represented minorities (URM) and first-generation college students in STEM fields. Studies have suggested institutional and faculty-level changes that could reduce the achievement gap for minority students. Faculty attitudes about retention, and an assumption that primarily weak students are the ones leaving the program can be barriers to widespread change. In the Mechanical Engineering (ME) department at our institution there is an intuitive understanding of the lack of diversity in our programs, but we have only recently begun utilizing institutional data to understand our student body and the success or lack of success in different student populations. This study presents data obtained through a collaboration with our Analytics and Institutional Research department in our first attempt to understand more specifically the numbers around student persistence and retention in our program. This paper describes the results and implications of our project. Findings included that students from under-represented minority groups and first-generation college students do not succeed in our programs at the same rate as students not in those groups, and that female students succeed at higher rates than their male counterparts. This is consistent with the literature and powerful data that we hope can be used to motivate ourselves and our departments to meet our students where they are and improve success for all students. This project informed us on *who* is leaving our programs, and now we want to learn more about *why* and begin to strategize about how we can better serve students at a course, department, and School level.

Introduction

For decades, studies have called for attention to recruiting and retaining a diverse student population in STEM fields [1, 2]. These studies have documented the achievement gap for under-represented minorities (URM) and first-generation college students [3-5]. Within the Engineering field, recruiting and graduating a diverse student body has been a focus for many years, as the demand for engineers continues to increase [6]. Students from under-represented minority groups, students who are the first in their family to attend college, and low-income students have lower success rates in college in general, and this trend is true in engineering [7]. In 2016, 61% of engineering bachelor's degrees were awarded to white students, 11.3% to Asian-American students, 11% to Hispanic students, 4% to black students, and only 0.3% to American Indian or Alaska Native (AIAN) students [8]. ASEE reports that in 2015, the national average for six-year graduation rates is approximately 60% for white students and approximately 45% for Hispanic/Latino students, 38% for Black or African American students, and 45% for AIAN students [9].

First-generation students are defined as undergraduates whose parents/guardians do not have a bachelor's degree. First-generation college students make up about a third of all undergraduate students, but only 20% will graduate with a bachelor's degree, compared to 42% for continuing generation students [10]. First-generation students come disproportionally from under-

represented minority groups as well, with Hispanic students being three times more likely to be first-generation than continuing generation students [10].

Students leave engineering for a variety of reasons, the most pervasive of which may not be the academic difficulty of the programs. Multiple studies have investigated why students leave engineering. In a review of fifty studies on student attrition from engineering programs, Geisinger and Raman found six factors that drive students to leave: classroom and academic climate, grades and conceptual understanding, self-efficacy and self-confidence, high school preparation, interests and career goals, and race and gender [11]. In a multi-year study at a single institution, another study narrowed it down to three factors causing students to leave: poor teaching and advising, curriculum difficulty, and lack of belonging [12], and interestingly found that the lack of belonging factor was the biggest reason why students left, regardless of gender and race/ethnicity. The same study found that female students who left the program were stronger, academically, than male students who left (GPA of 3.20 compared to 2.95). Students with higher GPAs found the academic factors to be less of an influence for leaving. First generation students experience many of the same factors, but more first-generation students report leaving due to not being able to afford school or a change in family status, compared to continuing generation students [10].

Studies have suggested institutional and faculty-level changes that could reduce the achievement gap for minority students [13, 14]. For example, increasing course structure, increased transparency, and active/cooperative learning have been shown to increase success for all students, but particularly students from under-represented groups [15, 16]. Faculty attitudes about retention, and an assumption that primarily weak students are the ones leaving the program can be barriers to widespread change [17]. If faculty are more aware of who is leaving the program, then this assumption can be challenged and one more barrier to change lessened. This paper will describe a project in one engineering department that aimed to better understand the students who were leaving the program, with the long-term goal of motivating change in order to better serve all students, but especially our students from under-represented groups.

Background and Motivation

In the Mechanical Engineering (ME) department at our institution there is an intuitive understanding of the lack of diversity in our programs, but we have only recently begun utilizing institutional data to understand our student body and the success or lack of success in different student populations. Data analysis of University retention for those who began in Mechanical Engineering (but may go on to graduate from a different program within the University) between Fall 2010-Fall 2014 shows a lower graduation rate for students who are under-represented minorities (URM) compared to those who are not, and first-generation college students compared to continuing generation students (Figure 1). Females have the highest 6-year graduation rate, and are more than 10% higher than their male counterparts. Although these graduation rates were higher than the national averages [9], the reduced graduation rates in the URM and First-Generation categories were nonetheless disturbing.

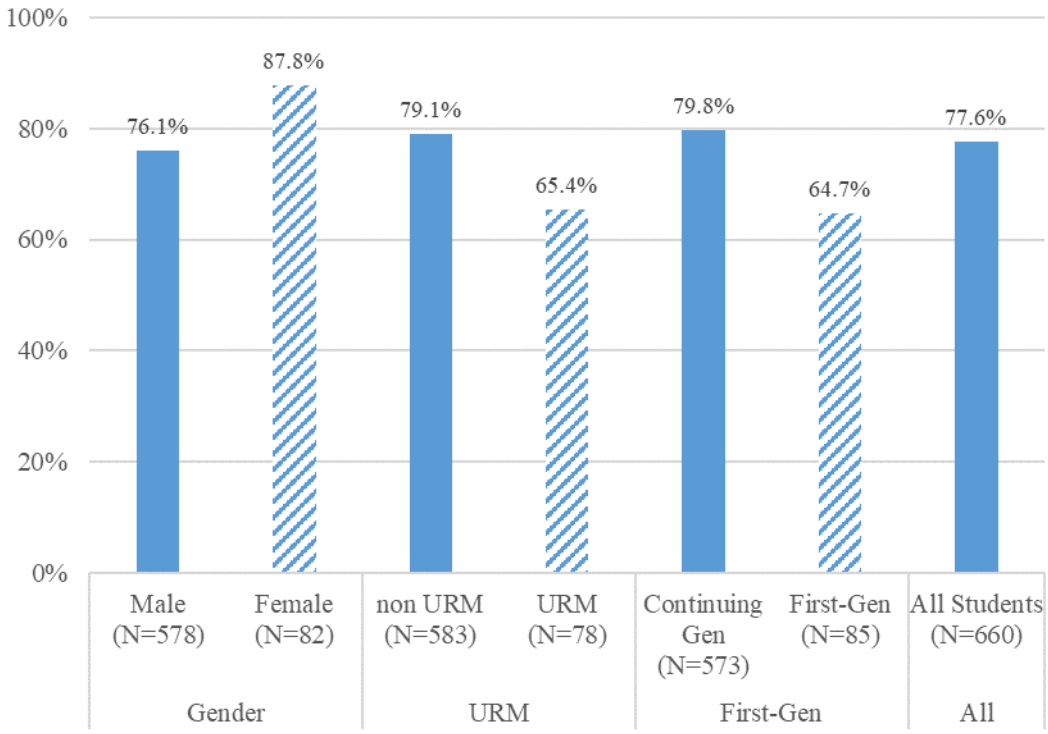

Figure 1. University Graduation Rates for Cohorts Starting in Mechanical Engineering in Fall 2010-Fall 2014. URM= Under-represented minority, First-Gen = First Generation college students.

Therefore, a group of faculty in the Mechanical Engineering department collaborated with our institution's Center for Teaching Excellence on an initiative which allows us access to institutional data to help drive action plans to address these important issues. Through this initiative, our department is working to understand student success in our programs, particularly for females, under-represented minorities, and first-generation college students. The goal of this initial project was to better understand where we stand as a department in terms of success for these students, develop plans to reduce barriers to success, and utilize what we learn from this project to promote change in our department. This study utilized institutional data provided by the Analytics and Institutional Research department and the paper will describe the results and implications of our project, specifically with respect to the following questions:

- *Is the mechanical engineering curriculum "equal opportunity?"* We investigated grade distributions (number of A, B, C, D, F, W) and DFW (Drop, Fail, Withdraw) rates in 200, 300, and 400 level courses in the ME curriculum for all students and for students from under-represented minority groups.
- *Who is leaving our program, what is their performance when they leave (GPA at departure time), and what is their educational outcome?* We quantify the percentages of students leaving the program by those who later graduate from our institution with a different degree, those that leave our program and institution, and those that leave our program, enroll in another program, and then later leave the institution. We look at this data by gender, URM, and first-generation groups. We also look at the GPA of students who leave the program.

Methods and Results

Is the mechanical engineering program "equal opportunity?" To investigate this question, we looked at DFW rates in all courses in the ME curriculum, and compared DFW rates for "all" students to female students, URM students, and transfer students. At this time this is the only data we have on DFW rates in courses and it was not possible to break this down by other demographics. This data included all courses in the ME curriculum: three 200 level, four 300 level, two 400 level, three 500 level, and three 600 level courses. Typically, 200 and 300 level courses are freshman/sophomore courses, 400 and 500 level are junior level courses, and 600 level are senior level courses. This data included DFW rates for these courses from Fall 2014-Spring 2018. The number of students for each course across the time period ranged from 478-1250, with a median of 624.

Table 1. DFW rates for all courses in the ME curriculum between Fall 2014- Spring 2018. Numbers in table represent the range, average (AVG), and standard deviation (Std) of DFW percentages across each level of course. Table represents data from 10982 students enrolled in each of the classes (not unique students as each student must take each of the courses).

%DFW (Fall 2014-Spring 2018)					
ME Courses		All	URM	Female	Transfer
200 and 300 level	Range	5.7-27.5	9.3-33.1	5.1-20.9	9.1-27.0
	AVG (Std)	14.2 (7.0)	20.0 (8.4)	9.7 (6.5)	14.8 (6.0)
400 and 500	Range	0.6-12.8	0-15.6	0-10.4	0-15.4
	AVG (Std)	8.1 (5.9)	8.3 (7.3)	6.0 (4.4)	4.4 (6.8)
600	Range	4-14.9	0-19.1	2.2-11.1	0
	AVG (Std)	7.8 (6.2)	7.8 (10.1)	5.7 (4.8)	0 (0)
All	Range	0.6-27.5	0-33.1	0-20.9	0-27
	AVG (Std)	10.9 (6.9)	13.6 (9.9)	7.7 (5.6)	8.4 (8.4)

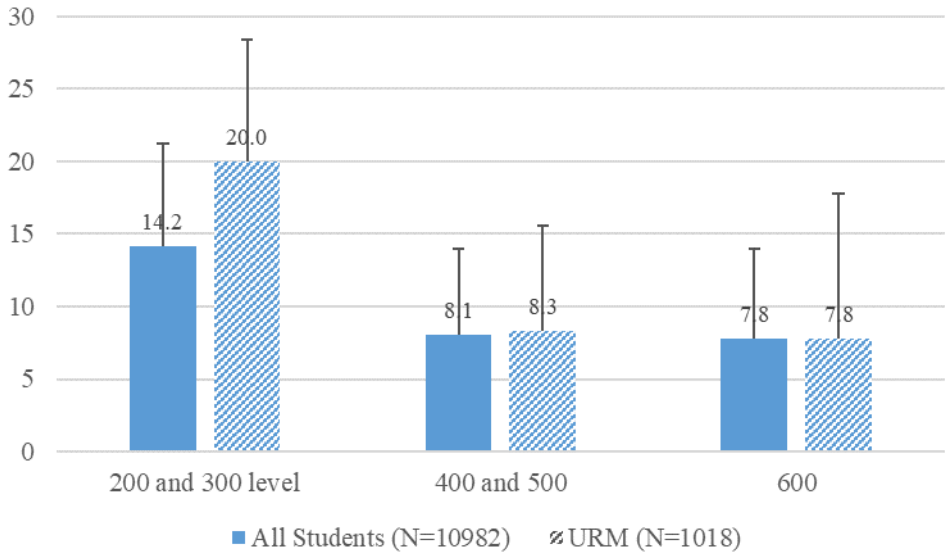

Figure 2. Average DFW rate in 200-300 level, 400-500 level, and 600 level Mechanical Engineering courses. Solid blue is average for all students enrolled in the courses between Fall 2014-Spring 2019) (including URM students), and the hashed blue bar is average for URM students only.

DFW rates for females and transfer students were typically similar or lower than the overall DFW rates, however DFW rates for URM students were typically higher than all students (Table 1 and Figure 2). Almost all of this increase in DFW rate occurred in the 200-300 level courses (Average 20% DFW rate for URM compared to 14.2% for all students), likely because those students getting D, F, and W's in the 200-300 level courses are then not going on to take the higher-level courses.

Who is leaving our program, what is their performance when they leave (GPA at departure time), where do they go, and how do they perform in their new home (i.e. GPA at graduation)? We investigate the GPA of students who leave the program, which department they go to, and their GPA at graduation, in each of the subpopulations.

To understand more about students leaving our program and those successful in our program, we investigated the outcomes and GPA for students who started our program in Fall 2010-Fall 2014 for a total of 660 students. We investigated the following outcomes: graduated from our institution with an engineering degree, graduated from our institution with a non-engineering degree, left the institution with no degree while still enrolled in our program, left the institution with no degree *after* they left our program, and left after 1 semester. As a whole, 63.2% of students graduated with an engineering degree, 14.4% graduated from the institution with a non-engineering degree, 12.4% left the university while enrolled in our program, 6.2% left the institution after leaving our program, and 3.8% left after their first semester in our program. Female students had a higher rate of graduating with an engineering degree compared to males (72.0% compared to 61.9%). The numbers for URM and first-generation students show a significantly lower level of success. For instance, only 55.1% of students from URM groups graduated with an engineering degree compared to 64.2% of students not from these groups.

Table 2. Academic outcomes for students starting in the Mechanical Engineering program between Fall 2010-Fall 2014, by gender, URM, and First-generation students. The grey rows highlight students that either earned and Engineering degree, earned a non-engineering degree from this institution, or left the institution with no degree (sum of left institution in ENGR no degree, left institution not ENGR no degree, and left institution after 1 semester.

Outcomes for students starting in ME Fall 2010-Fall 2014							
	Gender		URM		First-Gen		
	Male (N=578)	Female (N=82)	non URM (N=583)	URM (N=78)	Continuing Gen (N=573)	First-Gen (N=85)	All Students (N=660)
Engineering Degree	61.9%	72.0%	64.2%	55.1%	64.4%	56.5%	63.2%
Non Engineering Degree	14.2%	15.9%	14.9%	10.3%	15.4%	8.2%	14.4%
Left institution in ENGR no deg	13.5%	4.9%	11.3%	15.4%	11.7%	17.6%	12.4%
Left institution not ENGR no deg	6.4%	4.9%	6.0%	12.8%	5.8%	9.4%	6.2%
Left institution after 1 semester	4.0%	2.4%	3.6%	6.4%	2.8%	8.2%	3.8%
Left Institution with no degree	23.9%	12.2%	20.9%	34.6%	20.2%	35.3%	22.4%

Similarly, only 56.5% of first-generation college students graduated with an engineering degree compared to 64.4% of continuing generation college students. Another alarming outcome was that *more than a third of students* from URM and first-generation groups left the university with no degree (34.6% for URM compared to 20.9% for non-URM and 35.3% for first-generation students compared to 20.2% for continuing generation students).

Finally, we investigated the GPA of students who left our program *when they left* engineering. This included students who started our program in Fall 2010-Fall 2014 for a total of 660 students. Figure 3 shows the GPA of students who left our program. 14.4% (95/660) of students left the ME program and got a degree in a different program (non-Engineering) at this institution. The average GPA for these students when they left engineering was 2.74 ±.16. 12.4% (82/660) of students left the University without a degree while enrolled in the School of Engineering. The average GPA for these students in the semester they left was 1.93 ±.43). This most likely represents students who were either asked to leave or left on their own due to academic reasons. 6.2% (41/665) students left KU after leaving the School of Engineering without a degree. The average GPA for these students in the semester they left was 2.23 ±.20.

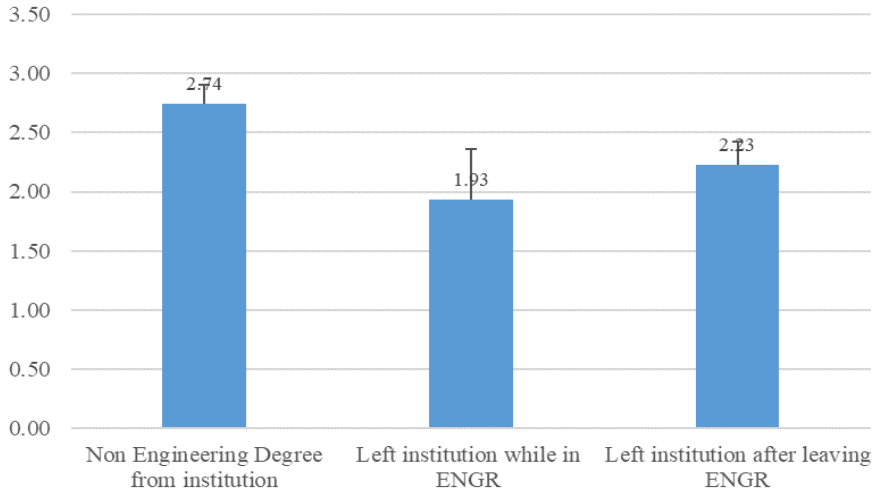

Figure 3. GPA of students at the time they left the Mechanical Engineering program, by academic outcome: Either earned a non-engineering degree from our institution after leaving our program, left the institution with no degree while enrolled in the program, or left the institution after leaving the program.

Discussion

This project aimed to inform one department about the educational outcomes of their students, and how under-represented groups of students are faring in their programs. While this data is often presented at an institutional level and can be read about in the literature at a more macro level, it seemed important for faculty within a department to understand these numbers for their students. The goal of this project is to first gain an understanding of who is leaving our programs and what can we do as faculty and as a department to keep more of the students that begin in our programs.

Based on the data presented through this project, we learned that students from under-represented minority groups and first-generation college students do not succeed in our programs at the same rate as students not in those groups, and that female students succeed at higher rates than their male counterparts. This is consistent with the literature [8-10] (and not unexpected, unfortunately) but still powerful data that we hope can be used to motivate ourselves and our departments to meet our students where they are and improve success for all students. One disturbing statistic that came out of this data is that *more than a third* of URM and first-generation students that begin our program leave the University without a degree.

We learned that students who do leave our program and go on to earn a different degree from this institution are leaving our program with an average GPA of 2.7. What we do not know is why these students left- if our students are consistent with what has been reported in the literature, these students are likely not leaving due to academic difficulty. Further study will compare this to the average GPA of students who stay in our program for comparison.

This project has informed us on the "state" of our program but is just the tip of the iceberg in terms of understanding why our students leave our programs and how we can impact more students, especially our URM and first-generation students. Our next step in this project is a multi-department collaboration within the School of Engineering to develop and roll out a survey to all students who are and have been enrolled in our programs, to hear directly from our own students which factors impacted their decision to leave the program.

Perhaps even more important than learning more information on why students have left (as most likely their reasons will also be consistent with all the other work in this field), is to learn about how to develop our programs and our environment to be more inclusive of all students. Much data exists in the literature on what these improvements might be. At the course level, instructors can be more transparent, use increased course structure, and adopt active and cooperative learning strategies, all of these have been shown to reduce the achievement gap and improve learning for all students [14, 18-21]. At the department and School level, we can investigate ways to improve advising, to broaden participating in peer mentoring and undergraduate research experiences, all of which have been shown to be high impact practices[12, 22, 23]. At all levels, we can improve our awareness of who our students are, ways to create a more inclusive environment, and commit to continuing education and development for our faculty around inclusiveness and evidence-based teaching. It is our hope that being aware of this data about our students and then by hearing from them directly through the survey that we will, as a department, be motivated to make changes at all levels to become more effective and inclusive teachers, enabling more of our students to be successful in our academic programs.

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