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Persistence and the Pandemic: Retention of Historically Underrepresented First-Year Engineering Students Before and After COVID-19

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Work in Progress - Persistence and the Pandemic: Retention of Historically Underrepresented First-Year Engineering Students Before and After COVID-19

Motivation

This Work in Progress paper will describe patterns across race/ethnicity of first-year engineering student retention before and after the spring 2020 emergency transition to remote learning in the wake of the COVID-19 pandemic at a large public R1 university in the Southwest. The results of this study are expected to inform faculty and administration as they consider making policy changes in teaching and learning to improve the persistence of engineering students.

Introduction

Persistence in Engineering Among Historically Underrepresented Students

Engineering programs have some of the highest attrition rates among all degree majors, and despite efforts to improve engineering student retention, graduation rates have remained at around 50% over the past several decades [1]-[5]. First-year student retention in science, technology, engineering, and mathematics (STEM) programs is particularly important as students primarily leave STEM programs between their first and second years [2]-[8]. Seymour and Hewitt's [8] comprehensive review of attrition in STEM programs reports that roughly 35% of students leave STEM majors during the transition between the first and second year; most of these students switched majors, but some dropped out of college entirely. They also describe how attrition rates in STEM programs decrease dramatically after this initial loss, suggesting that student retention in STEM programs may increase if efforts are made to better retain first-year students [8].

A more recent report including over 100 U.S. universities found less extreme retention rates among engineering students— reporting that about 80% of engineering students persist to the second year [4]. However, persistence rates vary significantly among student demographic groups, with students from historically disadvantaged backgrounds demonstrating much lower persistence and graduation rates [1], [4], [5], [7]-[11]. The same report reveals that roughly 10% fewer Black and Hispanic students persisted to the second year of their engineering programs when compared to White and Asian students; in 2014, second-year persistence rates were 87% and 82% for Asian students and White students respectively, and only 75% and 76% for Black students and Hispanic students [4]. Similar patterns are found when observing engineering student graduation rates [5], [7], [9]-[11]— of all U.S. Bachelor's degrees obtained in engineering in 2020, roughly 5% were awarded to Black students, 13% to Hispanic students, 15% to Asian students, and 59% to White students [11]. Persistence rates in STEM have also been found to be lower for first-generation students, with one study reporting a 25% attrition rate in STEM degrees for first-generation students compared to the 13% attrition rate for continuing-generation students [12].

Reasons for high attrition and low persistence in engineering programs, particularly for students of color, are varied and complex. Geisinger and Raman [1] identified five common factors related to student attrition and retention in engineering in their review: classroom and academic climate, grades and conceptual understanding, self-efficacy and self-confidence, interest and career goals, and race and gender. The first discusses the "chilly climate hypothesis" of engineering and STEM programs in general, citing that engineering students have often reported leaving STEM and engineering due to the competitive environment and individualistic nature of the programs [1], [3]. In fact, both students who left and students who persisted described the culture as "hostile" [1], [13]. This individualistic culture of many engineering programs tends to be more harmful to students of color, who often feel greater obligations to help others and serve their communities [1], [8].

Additionally, first-year academic performance has been identified as a salient factor contributing to attrition within engineering programs; first-year GPA is often a strong predictor of persistence [1], [2], [9]. Moreover, pre-college preparation is a strong predictor of first-year GPA [1], [2], [5], and students from historically disadvantaged backgrounds are more likely to lack adequate high school preparation [5], [14], [15]. In a study using a large educational dataset on students in Florida, Tyson et al. [15] found that Black students, Hispanic students, and students in the free lunch program were significantly less likely to take and pass higher level science and mathematics courses in high school than Asian students, White students, and students not in the free lunch program, which is often used as a proxy for family socio-economic status. For example, around 50% of Asian students and 29% of White students received credit for science courses beyond Chemistry I, compared to only 20% of Hispanic students and 15% of Black students [15]. Because stronger math and science preparation in high school greatly contributes to persistence in engineering programs, racial disparities in K-12 education likely explain much of the attrition variance between racial/ethnic student groups. In fact, the same study on Floridian students found that Black and Hispanic students with higher level coursework preparation were just as likely to persist in STEM degrees as White students [15].

Last but certainly not least, the general underrepresentation of students and faculty of color within engineering programs likely also contributes to the higher attrition rates observed in students of color [14]. When comparing undergraduate engineering enrollment rates to overall undergraduate enrollment rates in the U.S., striking differences are revealed. In 2019, undergraduate enrollment rates for Black and Hispanic students were roughly 5% and 15% for engineering degrees compared to the 13% and 21% enrollment rates for Black and Hispanic students in all undergraduate degrees [10], [16]. Data on faculty demographics in U.S. engineering programs reveal similar deficiencies in diversity [14]. Not seeing many other students or professors in their programs who look like them may discourage students of color from persisting towards engineering degrees.

The Impact of the COVID-19 Pandemic

The COVID-19 pandemic has greatly affected engineering education. The transition of courses to online formats has proven particularly difficult for engineering courses, as many engineering classes rely on hands-on activities [17], [19]. In fact, engineering faculty considered the loss of lab-based, hands-on instruction as the biggest challenge in teaching during the pandemic [17]. As faculty have struggled with online teaching, students have struggled with online learning. The pandemic has worsened engineering students' mental health, most notably through increases in stress and anxiety [20], [21], as well as their motivation and engagement in their classes [17], [18], [22]. In a recent study conducted by ASEE, 61% of engineering students reported difficulties remaining engaged and motivated while working/studying from home [17]. Many students also lack the necessary tools for success in digital learning— [18] reports that over 25% of engineering students did not have reliable access to internet connection, and [17] reports that 47% of engineering students purchased equipment with personal funds to work from home. Furthermore, students from historically underrepresented racial/ethnic backgrounds are less likely to have access to a computer and reliable internet connection [18], [22].

The Current Study

Although many studies have come out on the impact of the COVID-19 pandemic on engineering education, few studies specifically examine the pandemic's impact on historically underrepresented student attrition and persistence in engineering programs [23]. The current study describes the pattern of retention rates for three sequential cohorts of engineering students between the spring semester of the students' first year to the following fall semester across racial and ethnic subgroups. We hypothesized that drop-out rates would be higher for the first-year students who experienced the emergency COVID-19 transition (2019-2020 cohort) as compared to two previous first-year cohorts (2017-2018 and 2018-2019 cohorts); we also hypothesized that drop-out rates would be higher for students who identify with an underrepresented racial or ethnic subgroup than for White students.

Methods

Through an institutional grant, we were given access to administrative data for all engineering students from spring 2014 through spring 2021 at a large R1 university in the Southwest. This data included a variety of information, but for the purposes of this study, we only extracted data containing race/ethnicity, first-generation status, and financial need level. We began by extracting data from three first-year cohorts who intended to major in engineering in fall 2017 (n = 3,452), fall 2018 (n = 3,559), and fall 2019 (n = 3,448). Those who joined engineering in fall 2019 were labeled the "COVID cohort" as they experienced COVID-19 impacts in spring 2020, and those who joined in fall 2017 and fall 2018 were labeled the "pre-COVID cohorts." Next, from the fall student data, we identified all first-year students who continued in engineering in the following spring semester (spring 2018, spring 2019, and spring 2020). To clarify, those who joined engineering in fall 2019 and persisted to spring 2020 were labeled the "COVID cohort," as they experienced the emergency COVID-19 transition to remote, online learning in spring 2020. Finally, we calculated the proportion of students within racial/ethnic who dropped out of engineering between the spring of their first year and the fall of their sophomore year. Racial/ethnic groups "American Indian", "International", and "Native Hawaiian" were not included in the study due to insufficient sample sizes. Of those students who continued with engineering into their sophomore year, we created a cross-tabulation (Table 1) for the race/ethnicity, first-generation status, and financial need level to examine if the intersections between these variables may explain any potential differences in attrition rates among cohorts.

Table 1

Of those who persisted to the following Spring semester, this table displays the number of students by cohort within each race/ethnicity group and financial need level, as well as first-generation status.

	Financial Need Level					
	[a] No Aid App.	No Need	Low	Medium	High	[b] First Gen.
Cohort Fall 2017/Spring 2018						
AA or Black	2 (2.44%)	16 (19.51%)	14 (17.07%)	14 (17.07%)	36 (43.90%)	26 (31.71%)
Asian	74 (17.21%)	123 (28.60%)	81 (18.84%)	34 (7.91%)	118 (27.44%)	84 (19.53%)
Hispanic or Latino	57 (7.17%)	169 (21.26%)	114 (14.34%)	85 (10.69%)	370 (46.54%)	372 (46.79%)
Multiracial	20 (19.80%)	40 (39.60%)	15 (14.85%)	8 (7.92%)	18 (17.82%)	13 (12.87%)
Other/Unknown	40 (71.43%)	6 (10.71%)	3 (5.36%)	2 (3.57%)	5 (8.93%)	3 (5.36%)
White	386 (21.87%)	671 (38.02%)	312 (17.68%)	158 (8.95%)	238 (13.48%)	202 (11.44%)
Cohort Fall 2018/Spring 2019						
AA or Black	9 (9.18%)	18 (18.38%)	7 (7.14%)	11 (11.22%)	53 (54.08%)	26 (26.53%)
Asian	125 (23.67%)	156 (29.55%)	64 (12.12%)	41 (7.77%)	142 (26.89%)	80 (15.15%)
Hispanic or Latino	50 (6.70%)	179 (23.99%)	106 (14.21%)	60 (8.04%)	351 (47.05%)	301 (40.35%)
Multiracial	15 (12.93%)	38 (32.76%)	34 (29.31%)	11 (9.48%)	18 (15.52%)	9 (7.76%)
Other/Unknown	61 (68.54%)	7 (7.87%)	7 (7.87%)	2 (2.25%)	12 (13.48%)	2 (2.25%)
White	369 (20.88%)	687 (38.88%)	328 (18.56%)	157 (8.89%)	226 (12.79%)	179 (10.13%)
Cohort Fall 2019/Spring 2020						
AA or Black	3 (4.41%)	12 (17.65%)	7 (10.29%)	7 (10.29%)	39 (57.35%)	18 (26.47%)
Asian	82 (15.59%)	183 (34.79%)	76 (14.45%)	40 (7.6%)	145 (27.57%)	102 (19.39%)
Hispanic or Latino	54 (6.78%)	210 (26.38%)	131 (16.46%)	75 (9.42%)	326 (40.95%)	306 (38.44%)
Multiracial	21 (16.54%)	60 (47.24%)	17 (13.39%)	12 (9.45%)	17 (13.39%)	11 (8.66%)
Other/Unknown	15 (57.69%)	2 (7.69%)	5 (19.23%)	0 (0.00%)	4 (15.38%)	1 (3.85%)
White	321 (18.79%)	751 (43.97%)	294 (17.21%)	148 (8.67%)	194 (11.36%)	170 (9.95%)

[a] Student did not apply for financial aid.

[b] First Gen.: First generation

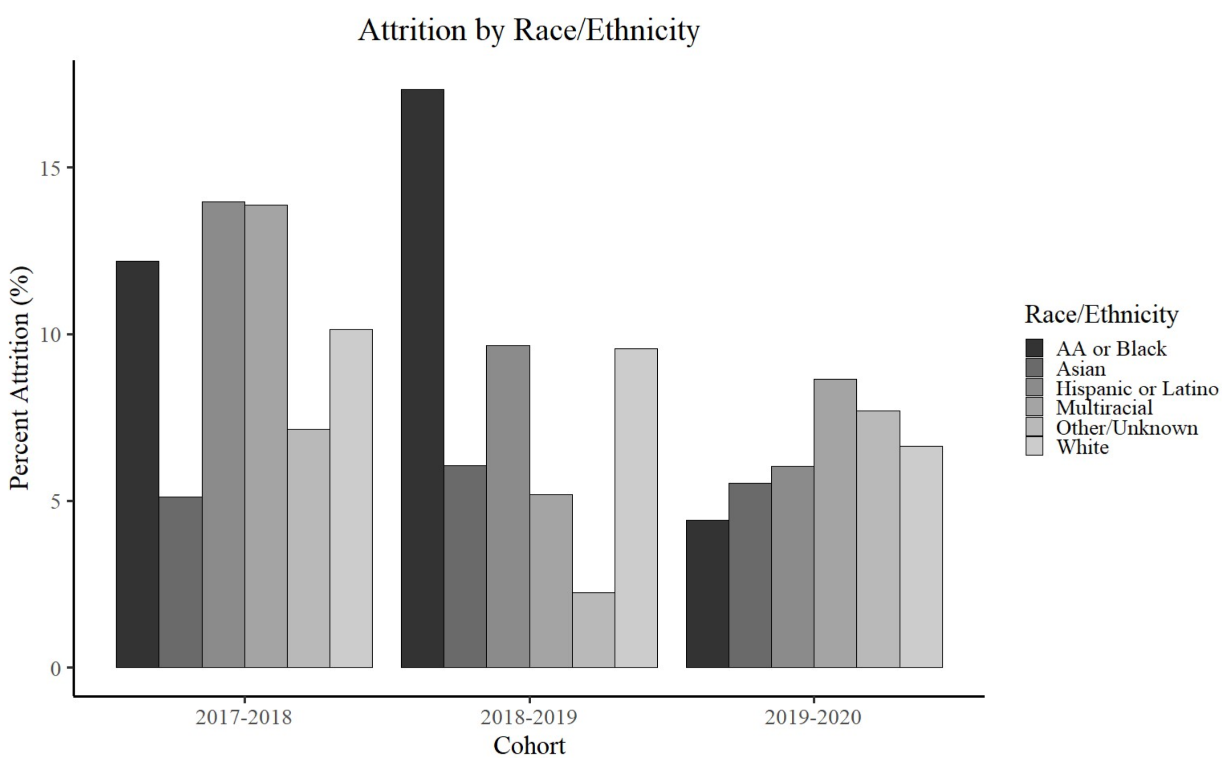
Note. Percentages for financial need levels are given as proportions across rows.

Results

Before examining the attrition rates, we first summarize the financial need and first-generation status across the three cohorts to determine comparability of the cohorts. When looking at the cross-tabulation displayed in Table 1, there is a decrease in the proportion of Hispanic/Latino students with a high financial need level from the pre-COVID cohorts to the COVID cohort (pre-COVID cohorts: 46.54%, 47.05%; COVID cohort: 40.95%). The other groups of students were relatively stable.

Next, we turned to the attrition rates. As depicted in Figure 1, attrition rates in the COVID cohort (2019-2020) were lower than or remained relatively the same as attrition rates in the pre-COVID cohorts (2017-2018 & 2018-2019). The greatest differences are seen within African American/Black students who demonstrated a drop-out rate of 4.41% in the COVID cohort, compared to the 12.20% and 17.34% drop-out rates observed in the pre-COVID cohorts. Decreases are also observed in Hispanic/Latino students (pre-COVID cohorts: 13.96%, 9.65%; COVID cohort: 6.03%) and White students (pre-COVID cohorts: 10.14%, 9.56%; COVID cohort: 6.62%), while Asian students remained relatively stable (pre-COVID cohorts: 5.11%, 6.06%; COVID cohort: 5.51%). The last two race/ethnic subgroups present with large fluctuations and no discernable trend in attrition rates: Multiracial students (pre-COVID cohorts: 13.86%, 5.17%; COVID cohort: 8.66%) and Other/Unknown students (pre-COVID cohorts: 7.14%, 2.24%; COVID cohort: 7.69%).

Figure 1



Discussion

Contrary to our hypotheses, the results indicate lower drop-out rates during COVID-19, and this pattern was seen across several racial/ethnic groups. This potential decrease could be due to several reasons, which are all speculation. The university instituted multiple initiatives (e.g., pass/fail options for grading), students may have opted to stay in school rather than dropping out because the job market was bleak [7], and federal stimulus initiatives may have made it easier for students to return to school. However, the financial need for Hispanic students in the COVID cohort was less than the financial need of the two pre-COVID cohorts, and these results do not adjust for between cohort differences, which may obscure the pandemic's effects on first-year engineering student retention. While these results are contrary to our hypotheses, these results are descriptive in nature and should not be used as grounds for removal of supports for students from historically underrepresented groups.

Our future analyses include comparing adjusted dropout rates (e.g., accounting for financial need) and replicating this study with engineering students from an institution that is categorized as a historically Black college or university (HBCU).

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