A MULTI-INSTITUTIONAL CRITICAL EXAMINATION OF UNDERGRAUDATE ENGINEERING ACADEMIC PROBATION AND SUSPENSION POLICIES

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By

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ABSTRACT

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This dissertation provided insights for engineering programs to consider as they take responsibility for improving undergraduate retention and graduation outcomes, especially for programs working toward the goal of educational equity. My findings suggested that engineering programs and researchers should add environmental factors to their models for student outcomes of retention and graduation following academic probation and suspension. I chose the three-manuscript format for this dissertation for each paper to build on the findings of the previous one. This was because there was a lack of engineering-specific literature on factors associated with retention and graduation for students put on academic probation and suspension. My critical lens was informed by Critical Race Theory (CRT) experts, and not explicitly the five CRT tenants. These experts recommended a process for posing of research questions to examine institutional and not student deficits as well as suggested methods, analysis and discussion to interrogate who institutions retain and graduate best.

Manuscript 1 - Suspension Description

An exploratory descriptive manuscript, this co-authored paper examined trends of over and underrepresentation of first-time academically suspended engineers' (FASE) outcomes at the intersection of ethnicity and sex. Outcomes included return to engineering from suspension and graduation rates. The rationale for this study was based on a gap in graduation rates by student ethnicity and to kick-start a future examination of how suspension policies and institutional environments play a role in inequitable outcomes. Our sample included undergraduates matriculated at two selective engineering programs, both Predominantly White Institutions (PWI). Students were admitted between

Fall 2009 to Fall 2018 with term data from Fall 2009 to Spring 2019. There were 1,199 FASE students among the 20,043 undergraduates in our sample. The two institutions suspended six percent of students. We reported FASE outcomes in aggregate, namely institutions attracted 21 percent of FASE returners to engineering. Of FASE returners with enough semesters in the dataset, institutions graduated 73 percent. Consistent with literature, males and Black students were overrepresented within FASE students. By disaggregating by ethnicity and sex, we provided more nuanced trends. For example, while males were overrepresented among FASE students, White males were not. Where females were underrepresented among FASE students, Latino and Black females were not. Asian males were the only group overrepresented among FASE students and underrepresented among FASE returners. To build off these descriptive statistics of FASE undergraduates, we recommended future research and interventions based in creating greater equitable outcomes in engineering graduation rates.

Manuscript 2 – Probation Multilevel Modeling

A descriptive and inferential quantitative study, this paper examined which students engineering programs put on academic probation (AP) and their outcomes at the intersection of sex and ethnicity. Outcomes included voluntary return to engineering the subsequent semester and graduation from engineering. This research is important for engineering programs to know how their warning of low academic performance in the first semester is associated with who they retain and graduate. My sample included undergraduates admitted from 2001 to 2013 across 18 residential institutions who housed engineering programs. Out of the 49,095 students in their first semester in engineering, engineering programs put 6,025 (12.27%) on AP. For modeling the likelihood of return and graduating, I used Eccles's Expectancy Value Theory with a critical lens, including

environmental factors of student and faculty composition as well as policy standards. I found that 21.37% of the variance in returning after probation could be explained by knowing which institution the student attended. Student composition, as measured by how much a student differed from the student composition by sex and ethnicity, was a significant predictor for both retention and graduation. Engineering programs retained and graduated students who differed from the engineering student body significantly less than those who resembled the student body. Faculty composition was a significant predictor for graduation only. Engineering programs graduated students in engineering who differed from the engineering faculty significantly less. My findings point to the need for retention and graduation models to include environmental and policy factors and understand that factors may differ by retention and graduation. Engineering programs, professional organizations, and granting agencies should also act on this data to examine best practices across institutions to improve engineering graduation rates equitably.

Manuscript 3 – Suspension Multilevel Modeling

This quantitative paper statistically described and examined the likelihood of retention and graduation for students who engineering programs put on academic suspension (AS) at the intersection of sex and ethnicity. Literature is silent on the topic of how well engineering programs retain and graduate students following required removal from their programs and institutions. Institutions who aspire to be educationally equitable need this information to better understand who they serve best through academic policy, especially at the intersection of sex and ethnicity. My sample was limited to nine engineering programs with student record data spanning years from 1988 to 2013 with 94,391 unique undergraduates who started in engineering. My sample was also limited to students with enough term data to be eligible to graduate, totaling 9,665 (10.24%)

academically suspended engineering students. I utilized a motivational framework, Eccles's Expectancy Value Theory, with a critical lens built in, as it included environmental factors. I chose to measure environmental factors through student composition as well as added policy standards. With 12.85% of the variation of retention and 8.40% of graduation explained at the institutional level, I chose a multilevel model to examine any association with environmental factors.

Student composition, as measured by how much a student differed from the student composition by sex and ethnicity, was a not a significant predictor for retention and was for graduation. Engineering programs graduated students in engineering who differed from the engineering student body significantly less. My findings suggest that environmental factors can vary in significance depending on a retention or graduation outcome and should be considered for future models. For engineering administrators, policy makers, I recommend a self-reflective examination of institutional data and, to what extent programs are willing, to take responsibility to move engineering education outcomes like degree completion toward greater equity.

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APPROVAL OF THE DISSERTATION

This dissertation defense, A Multi-Institutional Critical Examination of Undergraduate Engineering Academic Probation and Suspension Policies, has been approved by the Graduate Faculty of the School of Education and Human Development in partial fulfillment of the requirements for the degree of the Doctoral of Philosophy.

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DEDICATION

To my educators (Engineering and Education students, staff, and faculty) past and present, who continue to teach me how to interrogate how institutions can best support and challenge students to be their best self and realize their full potential.

To my family, who shaped my belief in myself and others.

To my pastor and faith community, who continue to point me to the need in our communities to love and show compassion with humility and introspection.

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To my fellow doctoral scholars, especially Ashley Woodard, Erin Hughey-Commers, Julia Lapan, thanks for encouraging progress in writing and making uplifting moments during the pandemic happen. To my coworkers and supervisors, who afforded me the opportunity to grow and learn. To my collaborators, Megan Harris and Kayla Brooks, for agreeing to allow me to lead the initial exploratory study across our institutions.

Most importantly, to my husband, Kyle Lampe. For keeping me grounded through a constant outpouring love and faith. You embody the characteristics I hope to see in the coming generation of engineering faculty and instructors – rigor balanced with support, inclusivity coupled with empowerment, and a lifelong pursuit of learning with humility. I could not have asked for a better spouse through my doctoral degree, birthing two sons, and muddling through the pandemic.

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LINKING DOCUMENT

Three Manuscript Dissertation Linking Document

This dissertation contributed to retention and degree completion literature in engineering by examining environmental factors associated with these outcomes. Critical Race Theory (CRT) informed my research lens through the recommendations of equity-minded researchers. These equity-minded researchers built their research from the foundation of the seven tenants of CRT, outlined by McCoy & Rodricks (2015): 1) the permanence of racism, 2) experiential knowledge, 3) interest convergence theory, 4) intersectionality, 5) Whiteness as property, 6) critique of liberalism, and 7) commitment to social justice. First, I aimed to ask different questions about educational outcomes because these scholars reminded me of the permanence of racism within the US, evidenced by the remedial instead of introspective stance higher education institutions default to when failing minoritized students (Bonilla-Silva, 1997). Second, I centered the narratives on Black females, utilizing student record data to tell their educational outcome stories, which has not been told previously and deserves more attention. Third, I understood that academic policies, which exclude some to benefit others (Lindo et al., 2010), worked in the interest of White students and the workloads of those who do not want to do the hard work to critically examine academic policies and environments to improve educational outcomes for minoritized populations. I also understood that the action to publish and defend this scholarship may come at a cost to my ability to publish in certain domains dominated by White scholars and reviewers. Fourth, I conducted an *ex post facto* analysis of student records which limited my ability to examine other intersectional identities in addition to gender and race which take on other forms of oppression (classism, homophobia, etc). I suggested future research should examine

additional intersectionalities. Therefore, while my studies were reductionist in that they look at one intersectionality (sex * ethnicity), nonetheless, they examine policy and environmental factors instead of solely focusing on student level predictors. Fifth, I highlighted the absence of literature around academic standing policies that acknowledges the absolute right to exclude through administrators using academic suspension to remove students from the institution without examining the educational outcome. Sixth, through policy, higher education administrators hold power to dismiss students from the institution for seemingly race-neutral, objective measures of grades. I also criticized institutional approach to incremental change, which is evident through administrators focusing on incrementally increasing the standards, again, without critically looking at the outcomes of their actions. Overlapping with Interest Convergence, I recognized that change to improve the educational outcomes for minoritized students likely come when that change aligns with institutional self-interest, such as retention and graduation rates, which can affect recruitment and institutional rankings as well as financial sustainability. I suggested the power of dismissal should continue to be critiqued while an institution purports they are taking responsibility to create an environment and policies for equitable recovery from academic failure. Institutions and researchers should ask whose interest academic probation and suspension work for the most and the least. Institutions should also not take grades as an objective measure of students' learning or motivation. Instead they should radically change the way they use grades as a metric for exclusion, initially introspecting that they might be failing the student and aligning their culture to the motivational needs of the student. Finally, institutions should consider being socially just through distributing resources equitably,

not equally, and especially not targeted specifically for those who already have vast amounts of privilege and opportunity. Based on these CRT tenants, my recommendations included examining the institution as the source of deficit and interrogating educational outcomes and their direct relationship with environmental factors.

Literature Review Summary

Due to the majority of student departure occurring in the first year, engineering education research focused on first year retention models (Veenstra et al., 2008). Veenstra et al. found that students below institutional academic standards left engineering at higher rates, so there is need for greater understanding of academic standing outcomes, namely the outcomes of those put on academic probation (AP) or academic suspension (AS). In the last ten years, no engineering education literature has examined AP or AS outcomes. In addition, most retention researchers mentioning students on AP or AS located the source of the deficit at the student level by pointing to struggling students' lack of study skills and time management (Tinto, 2012), and failed to examine the policies or cultures of the institution as the deficit. Some retention literature even excluded students who were in academic jeopardy (McGrath & Braunstein, 1997). A descriptive policy article on academic policies within engineering recommended examining AP and AS outcomes, especially among minoritized students (Brawner et al., 2010).

I took a critical approach to forming my research questions, analysis and findings of who institutions put on AP and AS, as well as their outcomes. More general than engineering, we know that males and Black students were overrepresented among students institutions put on AP and AS (Burgess et al., 2000; Goldman et al., 2003;

Hamman, 2016). Are these same trends occurring within engineering where males comprise most engineering undergraduates? If female engineering undergraduates are underrepresented, are minoritized engineers such as Black and Hispanic female engineers also underrepresented among those institutions put on AP and AS? Institutions need more research examining their deficits through their academic standing policies, educational environments and outcomes to take responsibility for their engineering degree completion rates.

Academic Standing Definitions

Within engineering, Brawner et al. (2010) described academic standing policies and their trends over time. Brawner et al.'s common set of definitions helps standardize language for researchers. I adapted Brawner et al.'s last definition of grade point deficit to include Cogan's (2011) reframing of grade point status, not assuming a deficit. It is important to note that grade point averages (GPAs) compose the infrastructure for academic standing policies.

> **Academic Good Standing (AGS)**: a semester (SGPA) or cumulative grade point average (CGPA) that is high enough to avoid all academic penalties.
> **Academic Probation (AP)**: an SGPA or CGPA that is lower than is required to be in academic good standing. Students may remain continuously enrolled, perhaps with conditions. Those returning to school after serving an academic suspension may also be on probation until they meet the requirements to be in good standing.
> **Academic Suspension (AS)**: requirement to separate from the university for a period of time, usually a semester or an academic year. Students may be suspended more than once.
> **Academic Expulsion (AE)**: permanent separation from the university. May not return except under extraordinary circumstances and only by appeal to a university committee or through other special programs.
> **Grade Point [Status (GPS)]:** a mathematical relationship between credit hours and quality points earned where hours attempted times credits earned is less than [AGS] times the hours attempted. (Brawner et al., 2010, pp. 8-9)

Institutions use student record data to identify students in academic jeopardy and may

place a student on multiple academic standing statuses over the course of their undergraduate career in the absence of academic recovery. For example, AS typically follows AP if a student does not meet AGS. Following AP or AS, students may voluntarily depart an institution or their engineering major. I studied which students engineering programs retain within engineering after AP or AS. Other outcomes, which follow an exhaustive list by Tinto's (2012) types of departures, not parsed out in my study, were a student returning to the same institution and changing majors, leaving for another institution, or leaving higher education. I conducted an in-depth study of AP and AS outcomes within the institution where a student initially matriculated.

Retention Literature

In addition to Tinto's types of departure, he and Braxton are widely cited for their retention models within higher education, along with Bean & Metzner and Astin (Astin, 1993; Bean & Metzner, 1985; Braxton et al., 2013; Tinto, 1975, 1993). While Tinto's (1975) model focused largely on the student integrating into the academic and social environment, Braxton and colleagues shifted the retention models to consider contextual factors and empirically demonstrated that retention factors differed between residential and commuter institutions. Tinto's academic integration factors included student course performance, hours studying, and faculty interactions outside the classroom (Pascarella & Chapman, 1983). Social integration was measured through factors such as engagement in co-curricular activities and formation of friendships and romantic connections (Pascarella & Chapman, 1983).

I specifically chose to add to the literature through investigating environmental factors as measured by student and faculty composition as well as policy factors with key

limiting factors due to conducting research on archival data; that is, data already collected. My factors included who integrated students at the intersection of their sex and ethnicity (sex*ethnicity). Unfortunately, with the limited number of institutions capturing AS in the dataset and a larger graduation window needed, I was not able to include faculty composition in the third manuscript due to a lack of archival data overlap.

Conceptual Foundation: Eccles's Expectancy-Value Theory Framework

For my second and third manuscript, I utilized Eccles's Expectancy-Value Theory (EEVT) as my framework (Eccles, 1983, 2005; Wigfield et al., 2018). Much of the AP and AS literature failed to include policies and culture and instead focused research questions on student characteristics and motivations, using a student as deficit model and focused narrowly on AP or AS students who chose to return (Brady, 2008; McDermott, 2008; Suchan, 2016). I chose EEVT because the model included institutional factors of culture and beliefs as factors influencing the outcome of student retention and degree completion. Additionally, Eccles empirically tested the theory in the context of math education to examine factors influencing differential outcomes by sex in advanced math course enrollment. Thus, the domain and critical lens of the EEVT matched the context and research lens of my studies.

While Eccles's model included student perceptions and self-schema, I chose to not include these factors in my modeling due to Bensimon et al.'s (2016) admonition. She asserted that researchers keep asking the same question of what students lack in terms of effort, self-efficacy and goals, and fail to ask the question of why institutions and policies keep failing minoritized populations. Bensimon and colleagues named many of the student psychological responses in the middle section of EEVT. These variables included

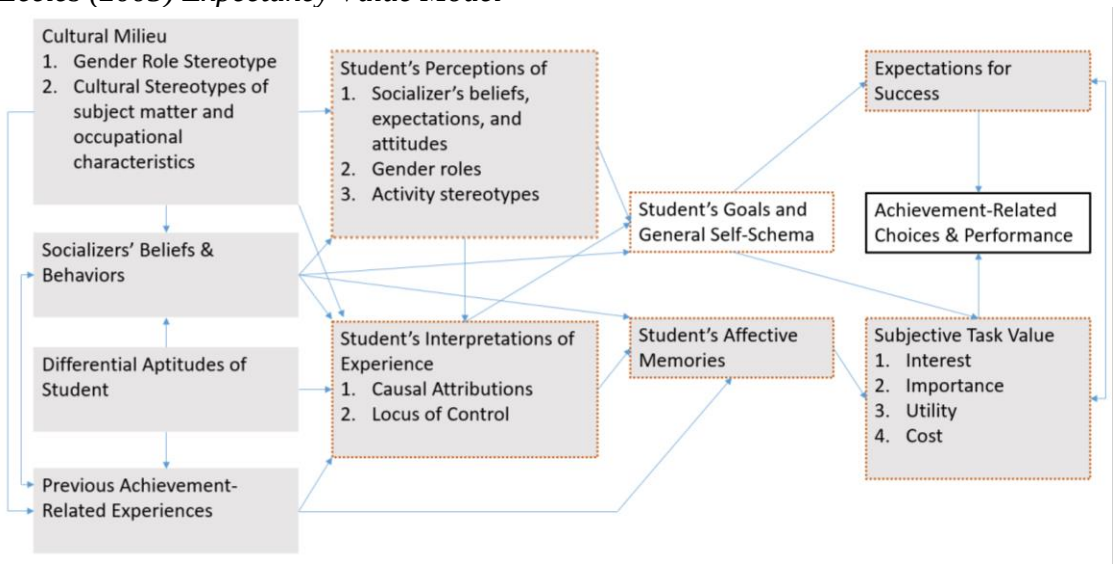
expectation for success, task value, a student's affective memories, goals and self-schema, perceptions of others' beliefs and expectations, and interpretations of their experience. Researchers found these variables differed by sex and ethnicity due to their socialization experience, which included cultural milieu and socializers' beliefs and behaviors (Eccles et al., 1984; Eccles & Jacobs, 1986). Therefore, as depicted in Figure 1**,** I chose to focus on the developmental factors within EEVT, namely cultural milieu and socializer's beliefs and behaviors. To provide a deeper understanding of the entire model, I described each variable and how it is measured, starting from the right to the left within Figure 1.

Achievement-Related Choices and Performance

The outcome variable of achievement-related choices and performance is an event

Figure 1

Eccles (2005) Expectancy Value Model



Note: Psychological components outlined with dots and developmental components shaded grey.

or social system (Matusovich & Streveler, 2010). Examples in higher education literature included college STEM course grades (Hsieh et al., 2012; Perez et al., 2019), count of passed STEM courses (Perez et al., 2019), midterm grades (Hsieh et al., 2012), continued enrollment (Matusovich & Streveler, 2010), STEM engagement outside the classroom (Nagengast et al., 2011), and long term academic choices (Nagengast et al., 2011). Nagengast et al. (2011) measured STEM engagement outside the classroom through the Science-Related Extracurricular Activities scale and long-term academic choices through the Career Aspiration in Science scale. For papers 2 and 3, I measured this outcome using retention and graduation.

The next six constructs in the EEVT model described attributes associated with the individual student and not the institution. The six constructs included a student's expectations for success, subjective task value, goals and general self-schema, affective memories, perceptions of socializer's beliefs, and interpretation of experiences. Because I chose to focus my research on institutional roles in facilitating student outcomes instead of student deficits, these six constructs were not included in my analyses in papers 2 and 3. I similarly excluded differential aptitude as a factor as it has been categorized as a static trait of an individual's intellectual ability and recently refuted by researchers (Dweck, 2009; Yeager & Dweck, 2020).

The final two constructs, Cultural Milieu and Socializers' Beliefs and Behaviors, are the portion of the EEVT model that focus on institutional factors, and thus are the two constructs I rely upon in the model most significantly.

Cultural Milieu

In literature, culture included a wide array of environmental factors surrounding a student. Work within science, technology, engineering and mathematics (STEM) utilized social structural theory by measuring culture through representation of diversity within the domain studied (Else-Quest et al., 2010; Parker et al., 2020). Allport (1954) argued that diverse representation of gender or ethnicity could reduce human prejudice through exposure to more diverse set of perspectives. Measurements of culture in papers 2 and 3 include the measurement of difference between an individual's sex*ethnicity and that of the student or faculty body at the time of an engineering student's admission.

Socializers' Beliefs and Behaviors

Eccles outlined beliefs and behaviors as both role modeling behaviors and messages students received from those important to students (Eccles, 1983). For example, Harackiewicz et al. (2012) created an intervention to increase high school student's math and science utility value through materials they provided to parents over a two year period. Students in the treatment group enrolled in significantly greater math and sciences courses compared to the control group. Lower achieving males and higher achieving females were responsible for the difference in treatment (Rozek et al., 2015). Researchers measured parental beliefs of utility of science through a questionnaire developed by Eccles and colleagues (e.g. Eccles, 1983).

Outside engineering education in the physical education field, researchers used EEVT to understand how parents' beliefs and behaviors influenced children's physical activity choices. Based on hierarchical regression analysis, the researchers found a parent's beliefs significantly and directly predicted their child's activity choices; whereas, their behavior or role modeling did not (Dempsey et al., 1993). I highlighted this study

utilizing the EEVT motivational framework to underscore the importance of examining direct relationships between socializers' beliefs and student behavior and do not intend to measure any parental involvement in AP or AS outcomes. In other words, where Figure 1 path analysis did not include a direct link between socializers' beliefs and behaviors, Dempsey et al.'s model did and so I intend to as well. Eccles (2005) more recently clarified why researchers ask socializers about their beliefs regarding students' abilities. Eccles remarked that there are conscious and unconscious influences on expectancies and values. The cultural milieu and a socializers' beliefs are often unconscious influences on a student's rational decisions (Elliot et al., 2018). For the second and third manuscripts to operationalize institutional AP and AS policies respectively, I measured socializers' beliefs and behaviors through AP and AS policies. Institutions utilize these policies to communicate their belief about a student's ability relative to their academic standards.

Linked Data Collection

The first manuscript informed the data collection process of the second two manuscripts. For the first paper, I utilized student record data from two institutions for exploratory purposes. Even with examining AS outcomes across two institutions over time, in my first paper I recommended expanding the dataset to more institutions over time. Therefore, I utilized the Multi-institutional Database for the Investigation of Engineering Longitudinal Development (MIDFIELD) for the next two manuscripts. Details on the narrowing of the dataset for the sample can be found in the manuscripts themselves. For the second manuscript, I utilized archival data from the annual American Society for Engineering Education (ASEE) for the faculty composition variable. Samples

varied in terms of being representative of U.S. undergraduate engineering programs. Research was approved through University of Virginia's IRB-SBS (#2433).

Linked Data Analysis

Due to the dearth of literature on AS outcomes in engineering, I chose to describe who engineering programs best retained and graduated following AS first. My analysis in the second two manuscripts was informed by the first. Like the first manuscript, I reported counts and percentages of students engineering programs put on AP in their first semester and AS across all semesters. I also reported the likelihood of retention and graduation outcomes in engineering to examine environmental factors. Due to institutions sufficiently explaining variation in each outcome, I utilized Multilevel Modeling (MLM), specifically logistic regression to build the models.

Linked Results and Discussion

I found examining environmental factors was important for engineering programs who aim to work toward educational equity and have the humility to examine how their environments might affect outcomes following AP and AS. My recommendations centered on policy makers, granting agencies, and those designing interventions to include environmental factors in efforts to increase educational equity. Lastly, I found key limitations due to archival research data in terms of size needed.

Manuscript 1

Through an exploratory descriptive analysis, I clarified the need for larger databases to sufficiently examine retention and graduation outcomes by sex*ethnicity following AS. Starting with 20,000 unique students, when around six percent of the students were suspended, the counts by sex*ethnicity were too small to report in terms of

retention and graduation. I delineated the importance of narrowing the entire sample to those who had enough terms in the dataset to provide a clearer narrative on retention and graduation rates. I also identified the need to examine engineering retention following AS not just the semester following return but also the subsequent semester due to some engineering programs requiring the returning to student to reenroll in engineering whether they continued to pursue that degree or not. Policy differences informed my examination on environmental factors in my second two manuscripts.

Manuscript 2

I reported environmental factors were significant predictors of engineering program retention and graduation following AP in the first semester. Namely, engineering programs were 6% more likely to retain and 431% more likely to graduate a student who most closely resembled the engineering study body by sex*ethnicity. Engineering programs were 85% more likely to graduate a student who most closely resembled the engineering faculty. It is important to note for future first year retention model development that faculty composition was not a significant predictor of retention, meaning some environmental factors might not be associated with retention when they are significant for graduation modeling in engineering.

Manuscript 3

For engineering program retention following AS, student composition was a significant predictor. Student composition was, however, a predictor of engineering program graduation. Engineering programs were 92% more likely to graduate a student who most closely resembled the engineering student body in terms of sex*ethnicity. This finding is important for future development of retention and graduation models.

There was a significant difference between capturing retention percentages the semester after a student returned from AS as compared to two semesters. Engineering programs did not retain 34.52% of students in engineering as compared to 46.32% the semester after returning from AS. This difference underscores the need for examining reinstatement policies in modeling retention following AS.

Future work depends on the expansion of MIDFIELD institution terms for participating institutions, and additional tables which capture policy difference over time and by institution. At the institutional and program level, a variable might include whether academic good standing is tiered by hours attempted and whether reinstatement policies require a student to reenroll in the engineering school. At the student level, it would be helpful to have a variable which captures whether they utilized course forgiveness or grade replacement.

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MANUSCRIPT 1/SUSPENSION DESCRIPTION

First-time Academically Suspended Engineering (FASE) Undergraduate Outcomes: Trends of Over and Underrepresentation at the Intersection of Sex and Ethnicity across Two Engineering Undergraduate Programs

The National Student Clearinghouse (NSC) Research Center recently reported the smallest increase of 0.3% in six-year college completion rates (Causey et al., 2020). Of those who started in a 4-year public U.S. institution, 67.4% completed that degree in six years (Causey et al., 2020). The percentage gap in graduation rates between Black and White students in four-year public institutions narrowed slightly from 25% to 23% from 2019 to 2020 (Causey et al., 2020; Shapiro et al., 2019). Among students who initially entered science, technology, engineering and mathematics (STEM) fields, completion rates were even more acute. Prior research has found that 48% of students left STEM fields within the six-year period of study (Chen, 2013). Within engineering, 41% of students left with 52% Hispanics and 60% Black or African American leaving (American Society for Engineering Education, 2016). These statistics can position the groups of students as the deficit instead of asking how US institutions have taken responsibility to adapt to the needs and motivations of a diverse student body.

To remain competitive in the global economy, the U.S. must meet the increasing demand of STEM jobs (Bureau of Labor Statistics, U.S. Department of Labor, 2018). The majority of STEM jobs are filled by white males and if minoritized populations were represented similarly with regards to initial interest, the shortage of STEM talent supply would be satiated (May & Chubin, 2003).

Within engineering, this gap furthers economic inequality and hinders our ability to meet industry demand for diverse engineering talent (National Academies of Sciences, 2007). We found no literature within the last three years examining academic standing

outcomes within conference proceedings of the American Society for Engineering Education or the *Journal of Engineering Education.* Therefore, we chose to report trends in outcomes of first-time academically suspended engineering (FASE) students, specifically return and graduation rates. The question remains, who do engineering programs retain following academic suspension (AS) and graduate? Accordingly, this study examined trends among FASE students' outcomes at the intersection of sex and ethnicity (sex*ethnicity) at two predominantly white, 4-year public research universities. The following three research questions guided the analysis:

1. To what extent did each institution produce over and underrepresentation between enrolled student and first-time suspended engineering (FASE) undergraduate percentages by sex*ethnicity?
2. To what extent did each institution produce over and underrepresentation between percentage FASE students and percentage FASE returning students by sex*ethnicity?
3. What were graduation outcomes of FASE undergraduates who return from suspension for those who returned to engineering and had a 6-year window within the dataset?

Literature Review

Institutions academically suspend students to ensure students persist toward graduation only if eligible. AS in tandem with academic probation, was intended to increase student awareness of performance and connect a student with resources to meet graduation requirements of 2.0 cumulative grade point average (CGPA). Because institutions graduate a lower percentage of minoritized engineers, we utilized Critical

Race Theory (CRT) methodology to research academic suspension outcomes (Patton et al., 2015).

CRT examines the "unequal and unjust distribution of power and resources along political, economic, racial and gendered lines" (Crenshaw, 1991, p. 5). We followed the CRT researcher recommendations as we formed research questions, analyzed student record data, and reported academic suspension rates. We formed our questions to frame how institutional factors might lead to inequity, conducted analysis of outcomes by sex*ethnicity, and focused discussion on future research needed to examine institutional factors (Patton et al., 2015). There are two reports that we built off of and further justify our utilization of CRT – one specific to engineering and the other more generic to undergraduates. The second and more general report examined suspension over time and across institutions and disaggregate by sex and ethnicity separately.

First, we examined how academic policies may lead to inequitable outcomes. Through policies such as AS, institutions exacted power in determining who they dismissed and who they deemed worthy of further educational opportunity. Equity-minded researchers suggested examining systems and policies as the source of deficit (Bensimon, 2018; Bonilla-Silva, 1997; Patton et al., 2015). Academic policies in engineering programs were complex in multiple ways - GPA cutoffs, length of suspension, number of suspensions allowed, and warnings might or might not occur prior to suspension (Brawner et al., 2010; Ebrahiminejad, 2019). To delineate these differences, prior researchers have detailed academic policies ranging from 1988 to 2018, specifically academic good standing (AGS) standards within engineering programs at nine institutions. The AGS GPA cutoff differed by institution and over time, with most

institutions increasing to the 2.0 standard by 2005 with the highest at the University of Colorado Boulder raising AGS to 2.25 by 2018. Academic suspension (AS) was defined as a "requirement to separate from the university for a period of time, usually a semester or academic year. Students may be suspended more than once" (Brawner et al., 2010, p. 9).

Second, we chose to conduct our analyses for this study by sex*ethnicity. Based on a statewide report on overall academic suspension (as opposed to engineering), we know that institutions placed students on AS at a higher rate by ethnicity as well as sex, independent of one another. The study described Oklahoma institutions in the 1990s, not specific to engineering, and reported percentages of academically suspended students (Burgess et al., 2000). This report by the Oklahoma Regents for Higher Education disaggregated percentages of students academically suspended by ethnicity and sex separately. For example, the average suspension rate at comprehensive 4-year universities within the ten-year dataset for Black students was 10.9% as compared to 4.1% of White students (Burgess et al., 2000). The Regents acknowledged across the board that the "percentage of undergraduate students suspended continues to be the highest for Black students" (Burgess et al., 2000, p. 6). In one academic year, the suspension rate for Black students was as high as 17.6% (Burgess et al., 2000). This report also disaggregated by sex: the average suspension rate at comprehensive 4-year universities within the ten-year dataset for male students was 5.9% as compared to 3.4% of females (Burgess et al., 2000). The Regents acknowledged that student resource expansion and correcting institutional deficits at Oklahoma 4-year institutions improved student retention

outcomes. However, when reporting the increased retention rates, the Regents failed to quantify the outcome and failed to examine the outcome by ethnicity and sex.

Methods

Institutional Background

This paper conducted a descriptive analysis of FASE undergraduates using student record, term-level data for students enrolled in one U.S. Mid-Atlantic and one U.S. Western engineering program admitted from Fall 2009 to Fall 2018. The institutions – University of Colorado at Boulder (UCB) and University of Virginia (UVA) – included in this study were public doctoral granting, Research I comprehensive universities with admission offer rates around 30%-40% in the engineering undergraduate school. Academic probation and suspension policies differed by institution. UCB shifted its probation and suspension policy from a 2.00 cut off to a 2.25 in 2011, the highest cutoff among academic standing policies. UCB also simplified its probation policy and limited the ways a student could be suspended in 2018. UVA moved its first-year probation cut off from 1.8 to 2.0 in 2014 with no changes in suspension policy. Both engineering programs allowed for return from academic suspension. Both engineering programs also hired student success staff in 2016 (UCB) and 2014 (UVA). These shifts will be factors in future publications as both institutions acknowledge their need to improve outcomes for their engineering students at the intersection of ethnicity and sex. This study served as a benchmark for future improvement and to examine trends to inform future changes to policies.

Data

Initially, the dataset included all undergraduates and we narrowed the sample to those ever in engineering between the Fall 2009 to Spring 2019 terms. With 20,043 ever engineering undergraduates in this sample, there were 1,199 FASE students. Similar to the Oklahoma report (Burgess et al., 2000), we utilized the Integrated Postsecondary Data System (IPEDS) categories – Asian, Black or African American, Hispanic, Native Hawaiian or Pacific Islander, Nonresident Alien, Race/ethnicity Unknown, and White – and binary sex categories – female and male. Due to small counts, we created an "Other" category to aggregate Native Hawaiian or Pacific Islander, Nonresident Alien, and Race/ethnicity Unknown. By institution, we reported the counts and percentages of students ever enrolled in engineering, counts and percentages of those students ever academically suspended, followed by counts and percentages of students who returned from suspension.

For example, Asian females composed 3.7% of the students enrolled in engineering at the two institutions from Fall 2009 to Spring 2019. Asian females composed 2.0% of suspended students. Next, we calculated the difference between enrollment and suspension to calculate difference in suspension percentage. Asian females were underrepresented on suspension by 1.7% (i.e. 2.0% - 3.7% = -1.7%). Similarly, Asian females were at representation parity among FASE returners (i.e. 2.0% - 2.0% = 0.0%).

For graduation rates across both institutions, we included FASE students admitted Fall 2009 to 2014 to allow time-and-a-half semesters to graduate and provided counts and percentages graduated. Our student record data collection and analysis were IRB approved (#2433) through UVA's IRB-SBS.

Results

Aggregated Results by Institution

The University of Colorado Boulder (UCB) suspended 8.3% of its students in engineering, 16.3% FASE returned to engineering, and of those with sufficient semesters in the dataset, 76.2% graduated from the institution in general and 70.5% within engineering. The University of Virginia (UVA) suspended 2.1% of its students in engineering, 54.4% returned to engineering, and of those with sufficient semesters in the dataset 67.3% graduated from the institution in general and 32.6% within engineering. In comparison, UCB suspended 6.2% more students than UVA and retained 38.1% fewer FASE students. However, UCB graduated 8.9% more FASE returners in general and 37.9% more within engineering. See Table 1 for these descriptive statistics.

Disaggregated Results

Our intersectional results delineated more nuance to findings. While males were overrepresented among FASE students, White males were underrepresented (-5.4%). See Table 2 and 3. While females were underrepresented among FASE students, Latinas and Black females were overrepresented (1.5% and 0.9% respectfully; see Table 3). Asian males were the only group overrepresented among FASE students and underrepresented among FASE returners, 1.6% and -0.1% respectively. While Black students were overrepresented among FASE students, Black males were overrepresented by 3.2% in comparison to Black females who were overrepresented by 0.9%.

Per our IRB protocol, we were not able to report the graduation counts within engineering by sex*ethnicity because all sex*ethnicity groups except White students were below 10 at each institution. We will note Asian males were most overrepresented

among engineering graduates (9.1% of FASE returners and 12.2% of engineering graduates). Lastly, disaggregating by ethnicity and sex and not at the intersection, the

Table 1

Total Enrollment, Suspended, FASE Return to Engineering Counts (Percentages) by Institution (Fall 2009-Spring 2019)

Institution	Enrolled	Suspended	Returned	Returned & Eligible	Graduate	Engineering Graduate
All	20043	1119 (5.6%)	256 (22.9%)	154	113 (73.4%)	90 (58.4%)
UCB	12563	1039 (8.3%)	169 (16.3%)	105	80 (76.2%)	74 (70.5%)
UVA	7480	160 (2.1%)	87 (54.4%)	49	33 (67.3%)	16 (32.6%)

Table 2

Counts (Percentages) of Enrollment and Suspension Data for males and Black students admitted (Fall 2009-Fall 2018)

	Enrollment	Suspended	Suspension Difference
Male	14328 (71.5%)	965 (80.5%)	9.0%
Black	459 (2.3%)	76 (6.3%)	4.0%

Table 3

Heat Map of Percentage Difference between Suspension and Enrollment, Between Suspension and Return at the Intersection of Sex and Ethnicity (Fall 2009-Spring 2019)

Ethnicity – Sex	Suspension Difference	Return Difference
Other – Male	5.4%	1.3%
Hispanic - Male	4.2%	0.9%
Black – Male	3.2%	1.6%
Asian – Male	1.6%	-.0.1%
Hispanic – Female	1.5%	0.1%
Black – Female	0.9%	2.2%
Asian – Female	-1.7%	-0.1%
Other - Female	-2.2%	0.0%
White - Male	-5.4%	-6.8%
White - Female	-7.5%	0.9%

Oklahoma report held true in terms of overrepresentation of Black and male students within engineering, overrepresented by 9% and 4% respectively (see Table 2).

Limitations and Improvements

Counting students who returned to engineering following suspension was complicated by the fact that UVA required students to return to engineering before transferring to another school within the institution, potentially leading to a higher return rate for UVA. For graduation rates, we captured a ten-year window of graduation for those admitted Fall 2009, which gave them a longer period to graduate as compared to the students admitted in Fall 2014. We also did not include transfer students admitted after Fall 2014 which we could have, based on their time-and-a-half (3-year) window. Lastly, we acknowledge the limitations of IPEDS categorical data for ethnicity and a binary variable for sex. To be able to compare to past research and to utilize the easiest counts of unique students, we fell short of diversity and inclusion efforts to be more inclusive of multiple ethnicities and a gender spectrum instead of a binary sex variable (Connelly et al., 2016; Rankin & Garvey, 2015).

Discussion

This study examined trends of return and graduation rates of first-time academically suspended engineering (FASE) students. We utilized a critical lens in order to track trends in outcomes for future work to examine any link to inequity through the distribution of power and resources with regards to ethnicity and sex. Policy makers and academic administrators lacked research examining AS outcomes in general. Without our description of trends, institutions may continue to implement change to their academic policies and resources without accountability to critically think through who returns to

engineering programs and who graduates among FASE undergraduates. Without any published data, institutions did not have a sense of what improvement might look like compared to other institutions. In addition to graduation rates disaggregated by ethnicity and sex, the American Society for Engineering Education's Institutional Research and Analytics should consider benchmarking AS outcomes similar to this study (American Society for Engineering Education, 2016). Engineering programs, at a minimum internally, should conduct similar analysis of their AS outcomes, especially by sex*ethnicity.

Based on Critical Race Theory (CRT), we followed recommendations to examine FASE outcomes (Bonilla-Silva, 1997; Crenshaw, 1991; May & Chubin, 2003; McCoy & Rodricks, 2015; Patton et al., 2015). First, we recommended a paradigm shift from students as the deficit to institutions and policies as the deficit. Second, in order to examine FASE trends by sex*ethnicity, we must examine FASE outcomes across institutions and over time to have an adequate dataset. Third, future research will require interdisciplinary researchers with different methodologies – quantitative and qualitative – with motivational and cultural lenses. Fourth, the findings of these outcomes and subsequent interventions should impact policies at the institutional, state and federal levels.

First and foremost, we encourage institutions to examine their data, over time and to adjust practices to not only identify students who are struggling but to take ownership of the environments and policies that potentially lead to overrepresentation on academic suspension and underrepresentation of FASE returners. In other words, when policy makers make changes to policy such as GPA cut offs, provide staffing or interventions,

they should continue to monitor any trends in outcomes and not merely be satisfied with aggregate outcomes. In the case of this study, these two institutions plan to continue to track outcomes for years to come after their increase in GPA cut off as well as implementation of student success staff. Cathy O'Neil (2016), in her book *Weapons of Math Destruction*, explained "we've seen time and again that mathematical models can sift through data to locate people who are likely to face great challenges, whether from crime, poverty, or education. It's up to society whether to use that intelligence to reject and punish them—or to reach out to them with the resources they need" (p. 2). In order to intervene and reduce inequitable outcomes, policy makers must first examine who they place on academic suspension, who returns and graduates, and strategically think about the resources they allocate to student success. To date, no study has reported how many students return from academic suspension in engineering, so this is the first.

An intervention that reduces academic suspension or increases return and graduation rates in aggregate is simply not enough. Institutions should interrogate if interventions or changes to policy lead to equitable outcomes. Bensimon (2018) recommended that institutions employ equity-minded or race-conscious change and accountability. Future research could examine how much of the percentage point gap is explained by institutions not attracting FASE returners from each group. There is a 23% gap in degree completion between Black and White students (Causey et al., 2020). How much of that gap is explained by FASE students not returning? How much of that gap is explained by returners not completing a degree?

Descriptive analysis of FASE students was the first step in raising awareness of outcome trends. We would like to partner with institutions who would like to track their

policy changes and interventions. This collaboration could include joining in causal or experimental research designs across institutions to examine graduation equity. In this study, we found greatest overrepresentation among positively and negatively stereotyped groups within engineering (Asian and Black males), so our inclination would be to recommend those with educational psychology backgrounds join in the research with a motivational lens, particularly interrogating outcomes based on environmental factors such as campus culture, mindset and stereotype threat (Eccles, 1983; Museus, 2008; Steele, 1997). A granting mechanism for funding future research could include the Howard Hughes Medical Institute's Driving Change initiative. This funding mechanism includes a more comprehensive approach to create sustained cultural change within research universities. The main aim is to include traditionally excluded STEM undergraduates to create a more robust supply of graduate students who then go onto lead within research universities.

Second, we want those conducting future research to be informed regarding the contextual knowledge that must accompany datasets such as the Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD). While large datasets will enable researchers to study FASE students by sex*ethnicity, we must do so in conjunction with environmental factors and academic policies. We recommend interrogating how the culture, student and faculty composition has on FASE return and graduation as well as the academic policies.

Past literature has not addressed how to count FASE returners. Based on the difference in return rates, we suspect that FASE return rates could be impacted by reenrollment policies outside of academic suspension. For example, UVA required its

students to return to the school of enrollment, likely increasing the count of students who returned to engineering. In contrast, UCB allowed students to reenroll into schools outside of engineering, likely decreasing the count of students who returned to engineering. Future research will need to consider the global pandemic and altered grading options, which serve as the basis for AS policies. For example, grading options were drastically altered during the pandemic at both of these institutions.

Third, to critically examine policy differences and inequitable outcomes, researchers will be needed across disciplinary domains. For example, shifts in policy will need both a quasi-causal analytical skill set coupled with qualitative research. Research methods might include quantitative analysis such as regression discontinuity or structural equation modeling by group, and qualitative analysis to examine stereotype threat or mindsets of administrators. For an institution with an overrepresentation in Asian or Black FASE students, we would suggest learning more about the model minority and inferior minority myth and interventions to reduce stereotype threat in return rates (Mitchell et al., 2014; Museus, 2008). Museus recommended administrators acknowledge the extra burden stereotypes play in learning with the goal to 1) minimize racial stereotypes and prejudices and 2) support messages and a culture where stereotyped individuals believe in their unique strengths and are valued as members of an academic engineering community.

Fourth, as researchers, we must disseminate findings of inequity on multiple levels – institutional, state, federal. As practitioners, we must be committed to not only trying what intuitively helps reduce inequity but also demonstrate how we have reduced inequities and be accountable in our initiatives. The recent policy and resource changes

we described will require at least a ten-year window across multiple institutions. We remain committed to share findings.

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MANUSCRIPT 2/PROBATION MLM

A National Study of Engineering Undergraduate Academic Probation Status: Likeliness of Retention and Graduating at the Intersection of Sex and Ethnicity

Introduction

A college degree has long been associated with higher earnings, critical thinking skills which benefit our workforce, and a more informed citizenry (Becker, 1994; Labaree, 1997). Education is a form of human capital, or the value of skill and knowledge someone brings to the workforce and society, the United States invests in. Industries often use degree completion as a signal of human capital. Unfortunately, not everyone who starts a college degree completes one. For example, the latest report by the National Student Clearinghouse (NSC) Research Center reported a 23-percentage point gap between Black and White student completion rates within four-year public institutions (Shapiro et al., 2019). This problem is exacerbated by the fact that tuition is rising at alarming rates, leaving non-completers with large amounts of debt yet no degree. The average public four-year institution increased tuition by 244% from 1980-1981 to 2010-2011 in real terms (Mettler, 2014). For this reason, governments and higher education interest groups have politicized retention rates in the United States (Johnstone, 2016; Mumper et al., 2016). They continue to ask to what extent universities take retention and degree completion as a priority and responsibility for all their matriculants.

These groups have paid attention to completion rates in science, technology, engineering, and mathematics (STEM) majors. STEM degrees enabled the U.S. to remain a leader in technological innovation and ensured a robust economy (Bureau of Labor Statistics, U.S. Department of Labor, 2018; National Association of Colleges and

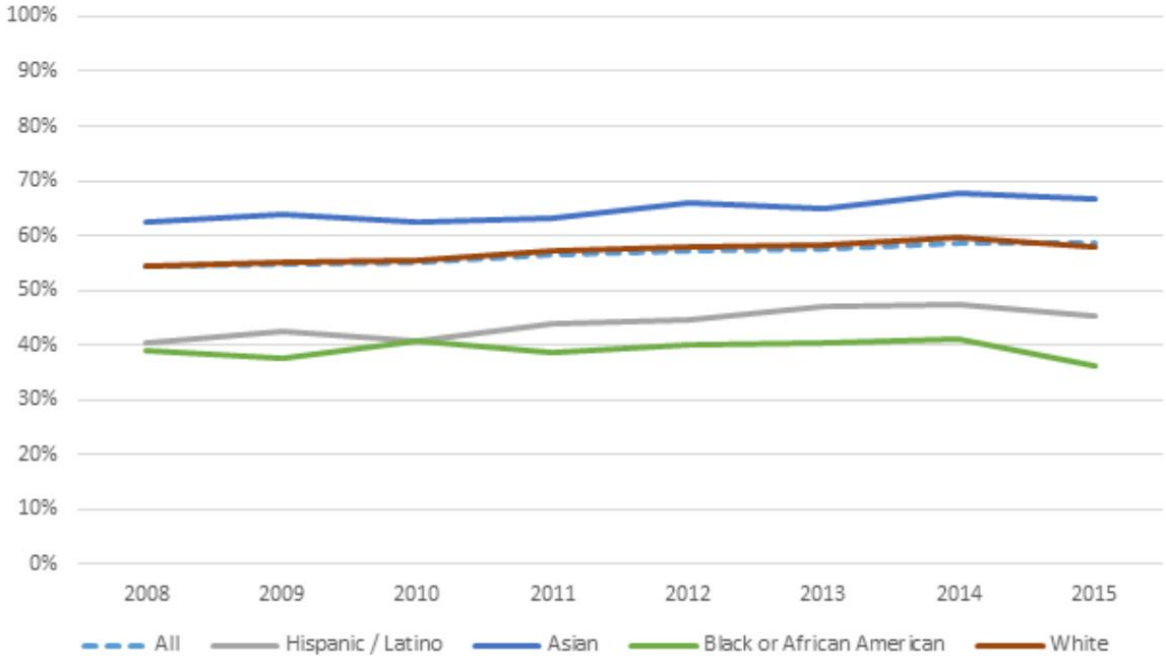
Employers, 2017). However, there is a critical shortage of minoritized students in engineering:

> America faces a demographic challenge with regards to its science and engineering workforce: minorities are seriously underrepresented in science and engineering, yet they are also the most rapidly growing segment of the population. (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2011)

Beyond representation, engineering has a long history of gaps in graduation rates for minoritized populations with institutions graduating Black and Hispanic engineering 20% and 10% below the average respectively (American Society for Engineering Education, 2016; Association of Public and Land-grant Universities, 2018). Institutions graduate White engineering students approximately around the average as they compose over 60% of engineering students in ASEE's national survey. Institutions graduate Asian

Figure 1

American Society for Engineering Education's 2017 Benchmark of Engineering Degrees Attained Within 6 Years



engineering students about 10% over the average. See Figure 1 for longitudinal trends. Researchers should examine engineering fields' success rates at retaining and graduating minoritized populations. Who are engineering programs best at retaining and graduating?

In their study of engineering student persistence, Veenstra et al. (2009) reported academic probation (AP) played a significant role in engineering student retention as the institution did not retain most of the students they put on AP. Veenstra et al.'s (2009) findings, coupled with a completion gap among ethnicities, begs the question of whether AP was associated with furthering the completion rate gap by ethnicity. Therefore, this study will examine the extent that AP and other environmental factors played a role in engineering completion rates at the intersection of sex and ethnicity (sex*ethnicity), and explored the following questions:

1. What percentage of students do engineering programs put on AP in their first semester, and does it differ across sex*ethnicity?
2. Is the likelihood of retention by AP status significantly associated with environmental or developmental factors?
3. Is the likelihood of degree completion by AP status significantly associated with environmental or developmental factors?

Significance of the Study

Within higher education research in general and not specific to engineering, retention models have served as foundational knowledge although they disagree on specific factors associated with retention in the first year (Braxton et al., 2013; Tinto, 1993). Unlike Veenstra et al. (2009) researchers found AP overall was associated positively with future performance and retention in aggregate (Albert & Wozny, 2018;

Burgess et al., 2000). In some studies, researchers disaggregated AP representation and outcomes by sex separately from ethnicity (Burgess et al., 2000; Hamman, 2016). However, there is no research examining the intersection of sex and ethnicity and the role of AP using one of the retention models.

Scholars examining policy outcomes with an equity lens call for an examination by sex*ethnicity (Bonilla-Silva, 1997; Crenshaw, 1991; Patton et al., 2015) and advise researchers to shift their examination of the source of deficit from the student to the institution (Bonilla-Silva, 1997; Felix et al., 2015; Patton et al., 2015). In my literature review section below, I explained in more detail how researchers found that academic suspension percentages differed significantly by sex as well as ethnicity. It is especially important in engineering as females are underrepresented in engineering and yet have better educational outcomes than males. This does not always hold true for all ethnic populations within the female group (Goldman et al., 2003). Researchers examining higher education outcomes utilizing an equity lens used both descriptive (Felix et al., 2015) and inferential statistics (Hamman, 2016). No study has examined AP representation or outcomes by sex*ethnicity.

Within engineering contexts, AP standards increased over time (Brawner et al., 2010) and engineering education researchers prototyped a first year retention model and tested factors explaining first year retention (Veenstra et al., 2009). However, no engineering education research has examined AP outcomes, with an equity lens or otherwise. Thus, this study contributes to the empirical literature by examining how sex and ethnicity intertwine with respect to AP and other environmental factor's association with the outcomes of engineering retention and graduation.

Literature Review

I specifically reviewed literature which pertained to 4-year institutions, which typically house engineering undergraduate programs. For this review, I : a) described how retention models differ in their predictors of persistence; b) defined AP policies and explain how policy makers have increased standards for good academic standing overtime; c) provided literature which reports aggregated and disaggregated academic probation percentages and outcomes; and finally d) concluded with how the literature suggested to interrogate the inequity of graduation rates.

Retention Model Predictors Differ

Over many decades, higher education researchers have developed models to describe factors important to understanding why students leave higher education and do not complete a degree. Most recently, Braxton et al. (2013) empirically tested a long established retention theory, Tinto's (1975) Interactionalist Theory. Tinto (1975, 1994) posited that institutions must fully integrate students both academically and socially to increase retention. Pascarella & Chapman (1983) measured academic integration as study habits as well as frequency of faculty interactions outside the classroom through a student survey to capture their first semester grade point average (SGPA). Pascarella and Chapman measured social integration through the number of weekends a student was around campus, co-curricular activities and peer relationships.

Braxton and colleagues (2013) empirically found academic integration was not a significant predictor of retention among first year students at residential colleges or universities. Braxton and colleagues found that institutional context, especially commuter versus residential colleges and universities, mattered when studying retention. Within engineering education research, Veenstra et al. (2009) tested these models to determine

significant factors in the first year retention of engineering students. In Veenstra et al.'s study, academic integration, as measured by performing well in coursework, was a significant factor of retention. Not only that, they also found a first SGPA below a 2.0 was predictive of student departure from engineering. This model was limited in generalizability due to the data source emanating from a single institution, the University of Michigan. University of Michigan's policy for academic good standing at the time was 2.0, which meant they warned or put students on academic probation if their first SGPA was below a 2.0, hence the finding that academic probation played a role in retention. Most students under a 2.0 SGPA left engineering.

Academic Probation Policy Definition and Standard Increase

To define academic probation policies, Brawner et al. (2010) provided a standard definition of academic good standing (AGS) as "a semester (SGPA) or cumulative grade point average (CGPA) that is high enough to avoid all academic penalties" (p. 8). Brawner et al. (2010) stated institutions put students on academic probation (AP), one type of penalty, when a student has "an SGPA or CGPA that is lower than is required to be in academic good standing" (p. 8). During probation, a student can remain enrolled the subsequent semester. Typically, the standard was a 2.0 SGPA because institutions require students to have a CGPA of 2.0 to be eligible to graduate as well as meet federal guidelines for financial aid (Brady, 2008; Brawner et al., 2010; Burgess et al., 2000; Hamman, 2016).

Based on one statewide Oklahoma study and descriptive policy analysis, we have a more nuanced story about AGS policies, namely they have increased over time. Not specific to engineering, the Oklahoma Board of Regents for Higher Education increased

AGS standards in the first year from 1.6 to 1.7 from 1991 to 1993 across all public higher education institutions in Oklahoma (Burgess et al., 2000). Specific to engineering, Brawner et al. (2010) described academic policies including AP at nine institutions. Ebrahiminejad (2019) similarly described AP policies at an additional 11 institutions. These descriptive studies are significant as many of these institutions provided their longitudinal student record data to the Multiple Institution Database for the Investigating Engineering Longitudinal Development (MIDFIELD). They reported these institutions, which all housed engineering programs, increased AGS standards overtime with the lowest standard being a 1.28 SGPA and the highest a 2.25 SGPA out of a 4.0 scale.

Aggregated AP Percentages and Outcomes

Through the increase in AP standards over time, the Oklahoma public institutions increased the percentage of students they put on probation. Comprehensive Oklahoma 4-year institutions put 3.7% to 11.2% of students on AP over the ten year dataset with an overall upward trend (Burgess et al., 2000). While we know from engineering education research that nine institutions increased their AGS requirements (Brawner et al., 2010), there is no research examining any trends in outcomes.

Researchers have found AP positive outcomes among STEM students and more generally (Albert & Wozny, 2018; Burgess et al., 2000). Through a quasi-causal method of regression discontinuity, Albert and Wozney found AP had a positive effect on STEM students at the U.S. Air Force Academy. Students on AP, just below the 2.0 SGPA standard, had better outcomes of graduation and reduced attrition as compared to their peers just above. AP increased subsequent SGPA by 0.141 and increased the probability of completing a degree among STEM majors by 13.9 percentage points (Albert &

Wozny, 2018). Albert & Wozny's study differed from other studies which found high rates of student departure following AP (i.e., Hamman, 2016), but their study may lack generalizability due to the institutional context and extreme intervention program associated with AP: students on AP at the Academy were required to create a plan for recovery, complete required study hours, and student's ability to leave campus over weekends were restricted.

Academic suspension was considered an outcome of AP if a student did not academically recover. In the Oklahoma report, at comprehensive 4-year institutions prior to the increase in standards, institutions suspended 3.0% of students; whereas, after the increase, institutions suspended 3.6% of students (Burgess et al., 2000). This report included a graph depicting the slight increase in suspension temporal to the standard increase, followed by a slight decrease. Retention and degree completion were considered an AP outcome. The Oklahoma report mentioned an overall increase in retention and graduation rates following the increase in AGS standard (Burgess et al., 2000). This mention lacked quantification.

Disaggregated AP Representation, Outcomes and Methods Limitations

While some research lacked disaggregated AP outcomes, they did disaggregate who institutions put on AP, or representation. For example, Albert and Wozney (2018) found that the Air Force Academy put a higher percentage of females on AP (25%) as compared to total enrollment (20%). They also found that the Academy put a higher percentage of nonwhite students on AP (33%) as compared to the total enrollment (23%).

For outcomes, some researchers examined subsequent enrollment (i.e. retention) following AP. In a binary logit regression model, Hamman (2016) found females were

less likely (β = -0.171, $p < .05$) and Black or African American students were more likely (β = 0. 542, $p < .01$) to be retained by an institution after AP. Researchers also measured academic recovery as an outcome of AP, as measured by SGPA following AP. Using multiple regression, Hamman (2016) found females placed on probation were more likely to academically recover (β = 0.273, $p < .01$) whereas ethnicity was not a significant predictor of academic recovery ($p > .1$). Lastly, researchers also considered academic suspension as an AP outcome. The Oklahoma report disaggregated by ethnicity and reported comprehensive 4-year institutions suspended Black students disproportionately during the increase in AGS. At the end of the AGS increase, for example, comprehensive 4-year institutions suspended 17.6% Black students as compared to 6.3% White students, a 11.3 percentage point gap (Burgess et al., 2000).

Even across several institutions over time, sample sizes were still small. For example, even across five Pennsylvania institutions over three years, Hamman (2016) aggregated ethnicity of students put on academic probation – Asian (n=45), Multiracial (n=81), Native American (n=7), Nonresident (n=4), and Unknown (n=95) – into an Other category. For this reason, studies in engineering education recommended studying degree completion rates over multiple institutions over time (Zhang et al., 2004). This limitation and recommendation informed my methodology and selection of data source.

Intersection of Sex and Ethnicity

Because the literature demonstrated significant differences in outcomes by sex as well as ethnicity, it is important to interrogate outcomes at the intersection of these demographic groups, utilizing a critical lens. Within quantitative research, Baez (2007) asserted that criticism, as rooted in Critical Theory, is the "judging of society…for the

purposes of exposing hidden power arrangements, oppressive practices and ways of thinking…[and serves] the purpose of changing society" (p. 19). While some AP representation and outcomes research detailed significant differences by sex and ethnicity separately, equity minded higher education researchers recommended reexamining widely studied topics critically and at the intersection of sex and ethnicity (Crenshaw, 1991; Patton et al., 2015). As a reminder, Hamman (2016) reported females were less likely and Black or African American students were more like to return following AP; however, we lack an intersectional outcome examination of Black females, who likely experience multiple forms of minoritization in engineering. Equity minded researchers would also criticize Hamman's (2016) location of deficit due to the wording – the individual returning and not the institution retaining. While I assert persistence and retention are a joint venture between student and institution, with my critical lens, I focus on the institution's responsibility and utilize language that locates the deficit on the institution and engineering program.

Criticize Source of Deficit

Institutions utilize course grades and credits earned to detect students to place on AP. While data might tell us one thing about progress toward an engineering degree, it does not tell us the whole picture. In fact, the students institutions identify for AP are often the ones facing incredible difficulty from society, within their families and if institutions are honest, within the walls of the institution. O'Neil (2016) urged educators to think about how they use the data – for exclusion and punishment or to provide students with the resources they need to learn, develop and succeed. For example, studies within the "Journal of College Student Retention: Research, Theory & Practice" focused

on student level demographic information to point to the need for special programming to address at risk populations (Hamman, 2016; Trombley, 2000). Beyond student level programming, (Bonilla-Silva, 1997) shifted the focus of the deficit to not just remediating the student but also thinking about systems and policies as a source of improvement. Researchers have not examined AP policies nor the makeup of faculty and students who compose an engineering program. The composition of an engineering program could be a source of deficit which needs improvement. While achieving 100% retention is unrealistic, engineering programs should not aim to improve their retention without asking who they have made strides in retaining. Instead I believe engineering programs should examine and be honest with themselves about who they support best in their efforts while improving retention. For example, if they retain females in general at high rates, then they should ask if this holds true for Black and Hispanic females. The intersectional (sex*ethnicity) analysis is warranted.

Equity-minded researchers suggested revising research questions by reconfiguring our location of the deficit from the student to the institution (Bensimon, 2018; Bonilla-Silva, 1997; Patton et al., 2015). Instead of Hamman's (2016) analysis that female populations are less likely to return, a critical lens would rephrase this analysis as institutions were less likely to retain females after AP. Within engineering education research, instead of asking what demographic factors or previous performance predict degree completion (Zhang et al., 2004), I asked how AP policies and environmental factors played a role in retention and degree completion by sex*ethnicity.

Research Framework

Within Veenstra et al.'s (2009) first year retention model, Tinto's Interactionalist

Theory and Braxton's examination of institutional factors, I specifically was interested in examining factors of academic integration and composition of faculty and students with associated retention outcomes. As Veenstra et al. recommended, I investigated an institution's retention of an engineering student following AP after the first semester. I also added to the literature by examining the outcome of students on AP graduating in engineering. This addition was because retention models were developed out of the impetus to understand how to increase degree completion, or graduation.

Instead of utilizing the newly developed retention model by Veenstra et al. (2009), limited in its generalization due to limited empirical testing, I chose a motivational framework generally used within engineering education literature (Brown et al., 2015) and which included institutional level factors as predictors of student outcomes: Eccles' (1983) Expectancy-Value Theory (EEVT). This framework could help illuminate the academic integration and institutional factors associated with retention outcomes of Veenstra et al.'s first year retention model. EEVT empirically tested factors influencing student persistence and included environmental variables. Testing environmental factors aligned well with the recommendation to shift the focus of deficit to the institution instead of the student.

Eccles (1983) developed the EEVT model considering differential student enrollment, based on sex, in advanced math courses in high school. Females who academically performed equivalently to males enrolled at lower rates in advanced math courses than their male counterparts. Eccles (2005) empirically tested developmental and psychological components associated with increased motivation of persistence (see Figure 2). This model has stood the test of time and has been studied in a variety of

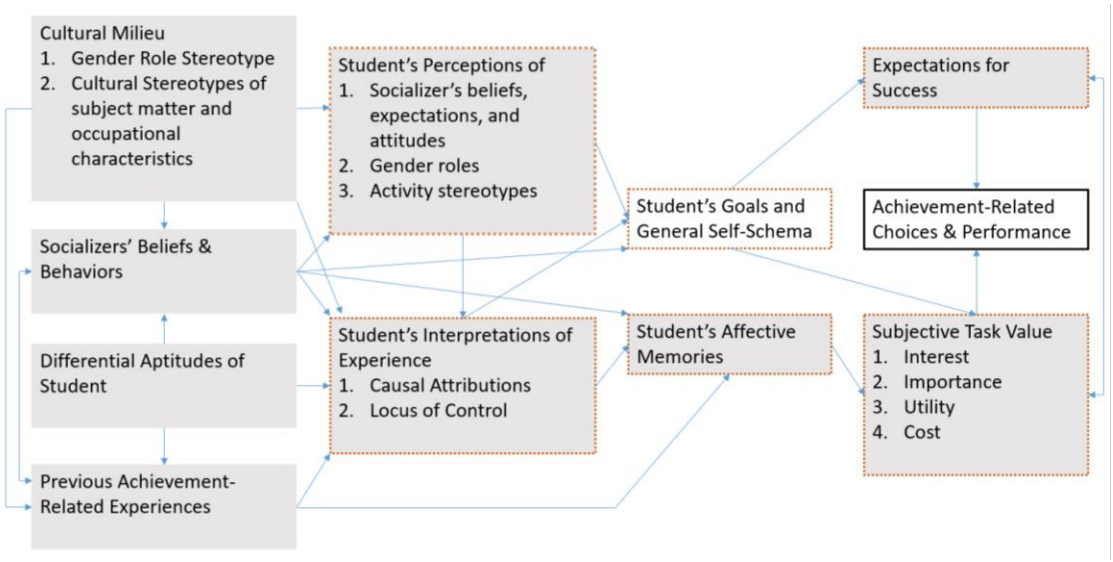
contexts, lending to the credibility of the model (Elliot et al., 2018; Wigfield et al., 2018). This theory has been utilized in postsecondary engineering education scholarship to understand why students decide to pursue engineering degrees (Matusovich & Streveler, 2010).

Applied Concepts of Theory to Study

Because I utilized a critical or equity research lens, I examined how culture, systems, and policies--all elements of an institution's environment--were associated with engineering programs' achievements of retaining and graduating students they put on AP. This reframing was different from past research, which focused on student achievement and motivation. Past research looked at student level predictors of academic success with regards to AP (Hamman, 2016; Trombley, 2000). I aim to examine institutional level

Figure 2

Eccles (2005) Expectancy Value Model



Note: Psychological components outlined with dots and developmental components shaded grey.

predictors of academic success with regards to AP. I defined engineering program achievement as motivating students to persist after AP and graduate within engineering. I utilized EEVT variables of cultural milieu, socializers' beliefs, and past performance to examine their association with the outcomes of retention and graduation (see Figure 3).

To quantify cultural milieu, I examined engineering-specific measurements of culture (see methods section below for data dictionary). Milieu literally means "middle" in French and in this context, the surrounding cultural environment in which students make choices about their achievements. Becher and Trowler (2001) defined culture within higher education as "sets of taken-for-granted values, attitudes, and ways of behaving, which are articulated through and reinforced by recurrent practices among a group of people in a given context" (p. 23). Researchers suggested not only examining the relationship between individual feelings and behaviors, but also consider the group or macro level factors. Parker et al. (2020) remarked these macro-structures emanated from power and inequality at the national level. In terms of measuring cultural milieu, critical psychologists noted more methodological work is needed (Fox et al., 2009; Parker et al., 2020).

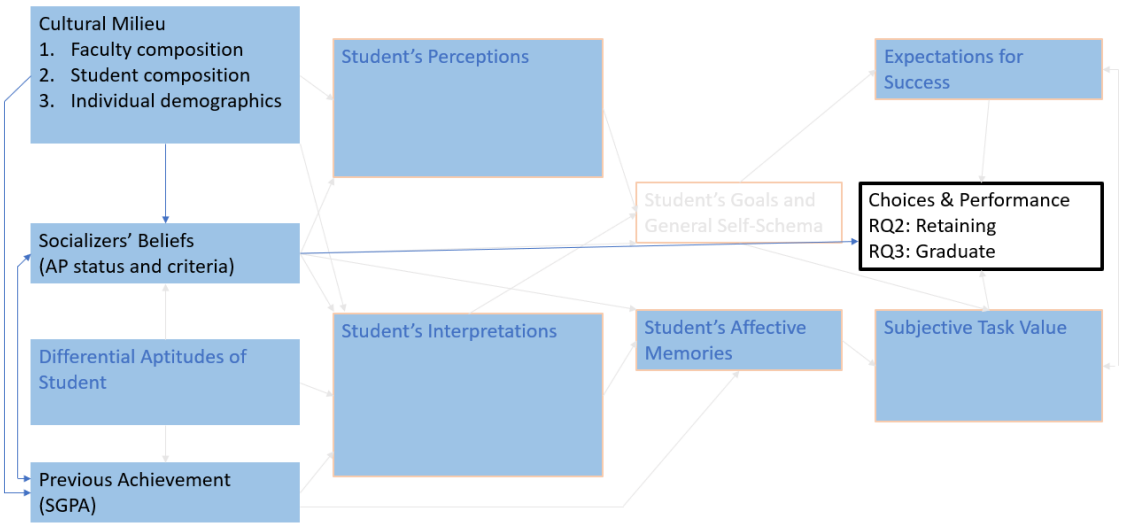
Parker et al. (2020) suggested one way to measure impact of culture in terms of its relationship to gender equity was through social structural theory or social role theory. Social structural theory contended the differences in gender performance and outcomes were largely explained by sociocultural factors such as what people expect females and males to do as well as what tasks were rewarded. Their argument stemmed from the observation that these variables provided an often-unconscious factor in behavioral choice, namely how people offered and encouraged opportunities for experience that

differ by gender. For example, if females are expected to care for others' emotional needs or prepare meals rather than spend time on coding a robot, their choices and behaviors may mirror expectations and value for their time.

Based on social structural theory, some researchers formulated several measurements of gender equity, included important moderators of ethnicity, age, social class, and publication era (Parker et al., 2020). Researchers have recently focused on national composite measures from two sources – the Global Gap Index from The World Bank and the Gender Inequality Index from the Human Development Reports (Else-Quest & Hamilton, 2018). More specifically, researchers measured gender enrollment ratios in education, the labor force, research positions, and parliamentary seats. In other words, the composition of the workforce in an environment impacted equitable outcomes. Within these gender and racial equity measurements, researchers found different

Figure 3

Adaptation of Eccles (2005) Expectancy Value Model to Explain AP Policy association with Student Persistence and Degree Completion



moderating effects on outcomes when they measured cultural milieu through specific domains, such as STEM, rather than a broader composite measurement of gender or racial equality (Else-Quest et al., 2010; Parker et al., 2020). Else-Quest et al. recommended measuring cultural milieu in the context of the study and not globally. Therefore, I measured engineering-specific sex and ethnicity measurements through each institution's engineering student enrollment and faculty composition. To measure socializers' beliefs and behaviors, I utilized AP status and AP policy criteria. I measured previous achievement through centering each student's first SGPA with the average first SGPA at their institution in that semester.

Methods

To review, the purpose of this study is to examine the extent institutional factors were associated with engineering completion rates at the intersection of sex and ethnicity (sex*ethnicity), and will explore the following questions:

1. What percentage of students do engineering programs put on AP in their first semester, and does it differ across sex*ethnicity?
2. Is the likelihood of retention by AP status significantly associated with institutional factors such as student and faculty composition? Academic policy standards in engineering?
3. Is the likelihood of degree completion by AP status significantly associated with institutional factors such as student and faculty composition? Academic policy standards in engineering?

I will describe the sample, measures, data collection, and analyses for this study in the following sections.

Sample

To study engineering undergraduates over time, my data came from the Multi-Institutional Database for the Investigation of Engineering Longitudinal Development (MIDFIELD), a dataset capturing student record data over time coupled with university catalogs from 1988 to the 2018. The database contained 18 residential institutions with 1,580,948 unique undergraduates. Institutions included Clemson University, Colorado State University, Elizabethtown College, Embry Riddle Aeronautical University – Prescott, Embry Riddle Aeronautical University - Daytona Beach, Florida A&M University, Florida State University, Georgia Institute of Technology, North Carolina A&T State University, North Carolina State University, Purdue University, South Dakota School of Mines and Technology, University of Colorado at Boulder, University of Florida, University of North Carolina Charlotte, University of Oklahoma, Utah State University, and Virginia Polytechnic Institute and State University. However, 10 institutions had enough terms in MIDFIELD to examine the graduation outcome. The ten were Clemson University, Colorado State University, North Carolina State University, Purdue University, South Dakota School of Mines and Technology, University of Colorado at Boulder, University of North Carolina Charlotte, University of Oklahoma, Utah State University, and Virginia Polytechnic Institute and State University (referred to as Institution A-J randomly assigned for anonymity as required by IRB protocol).

My second data source was the annual survey conducted by the American Society for Engineering Education (ASEE). The survey data included counts of all tenure and tenure track (T3) faculty from 2001 to 2018. The ASEE annual survey data included data

from all 10 residential institutions in MIDFIELD mentioned above and included the counts of faculty by sex and ethnicity by year and by institution.

From 2001 to 2018, there were 49,095 unique first semester engineering students in MIDFIELD who had enough terms to be eligible to graduate. In this timeframe, institutions put 6,025 (12.27%) engineering and pre-engineering first years on AP. The mean first SGPA for those on probation was 1.36 (s.d. = 0.56).

Measures

Based on an adaptation of the EEVT model (see Figure 3), I used quantitative variables from the MIDFIELD and ASEE datasets to measure cultural milieu (faculty composition as well as student enrollment differing from the individual sex*ethnicity), socializers' beliefs (AP status and policy components), and previous achievement (first SGPA mean centered within the institution). Based on prior (Allport, 1954) research which found ethnic and gender representation could reduce human prejudice, I operationalized cultural milieu through engineering faculty composition with the ASEE survey data as the source. I utilized a binary sex variable (male/female) and categorical ethnicity variable (Asian, Black, Hispanic/Latinx, International, Other/Unknown, White). Else-Quest et al., (2010) recommended to avoid using the majority population as the reference group in order to not further legitimize the majority populations as the standard and minoritized groups as the substandard. For this reason, I chose one of the minoritized populations as the reference group, Black females.

To determine whether a student had enough semesters in the dataset to be eligible to graduate, I used their transfer status, a binary variable. I allowed a six-year window in the dataset for first-time, first years and a three-year window for transfer students.

Data Collection

The MIDFIELD administrators collected and archived student record data at Purdue University. Data include all undergraduate, degree-seeking students at institutions who house engineering programs in order to examine longitudinal trends such as

Table 1

Data Dictionary for Research Questions

Variable (name)	Data Type/Source	Research Question: Use
Cultural Milieu		
Faculty Composition (cwc_fc)	Continuous variable (1 - percentage T3 faculty matched by sex*ethnicity, institution and year)/ASEE Survey	RQ2 & 3: Covariate
Student Composition (cwc_sc)	Continuous variable (1 - percentage students enrolled matched by sex*ethnicity, institution and year)/MIDFIELD	RQ2 & 3: Covariate
Sex*ethnicity Sex (sex) Ethnicity (race)	12 binary variables Male, Female/MIDFIELD Asian, Black, Hispanic/Latino, International, Other/Unknown, White/MIDFIELD	RQ1: Disaggregate by sex*ethnicity RQ2 & 3: Covariate of sex*ethnicity, Black females reference group
Socializers' Beliefs and Behaviors		
AP (prob)	Binary variable (0=no probation, 1=probation)/MIDFIELD	RQ1-3: Independent variable of interest
AP Criteria -SGPA (gcut)	Continuous variable/MIDFIELD Docs	RQ2 & 3: Covariates, examine correlation with AP status
-Other Criteria (ocut)	Binary (0=no added criteria, 1=students on probation above gpa standard)/ MIDFIELD Docs	

Variable (name)	Data Type/Source	Research Question: Use
Past Achievement		
First SGPA (cwc_fgpa)	Continuous variable (average GPA at Institution during year – student first semester GPA)/MIDFIELD	RQ2 & 3: Covariate
Outcome Variables		
Retention Subsequent Semester (ret)	Binary variable (0=not retained, 1=retained)/MIDFIELD	RQ2: Outcome variable
Graduate (grad)	Binary (0=not graduated in engineering by window, 1=graduated in engineering by window)/MIDFIELD	RQ3: Outcome or dependent variable
Data Management Variables		
Transfer (tran)	Binary (0=first-time first year, 1=transfer)/MIDFIELD	RQ1: Disaggregate RQ2: Covariate RQ3: Covariate & time-and-a-half horizon graduate condition
Major (cip6)	Six-digit code classifying major to filter by engineering students (14xxxx-15xxxx)/MIDFIELD	RQ1-3
Institution (institution)	Categorical Variable converted to unique id to merge with ASSE data/MIDFIELD	R2 & 3: Merging MIDFIELD and ASEE data
Student (mcid)	Unique id identifying student/MIDFIELD	R1: Unique student counts R2 & 3: Merging MIDFIELD tables

movement into and out of the engineering discipline. The database is comprised of four tables – student, term, course, graduate – and a collection of course catalogs which contain university policies and course offerings over time. Details of the full list of database variables are included on their website (Long, 2018). See Table 1 for variables I

used from MIDFIELD. MIDFIELD administration was funded by the National Science Foundation (NSF Award # 1545667).

The ASEE Annual Survey collected data from ASEE member institutions and included three main components – institution, faculty, and student. Within the institutional profiles, institutions reported faculty counts by sex and ethnicity. The survey was conducted from fall to January of each year. Participating institutions provided their data through a web-based survey instrument and were responsible for data accuracy. ASEE staff conducted a verification process and compared data to the previous year, contacting institutions with outliers as compared to previous year reporting (American Society for Engineering Education, 2021).

Analysis

For AP representation (RQ1), my research design included descriptive and inferential statistics. I reported counts, percentages and logistic regression and margins to report probabilities of students being put on probation. For AP outcomes (RQ2 and 3), I conducted a Multi-level Modeling (MLM) or Hierarchical Linear Regression in order to determine how much institutions and environmental variables influence AP outcomes.

Because each student was located within an institution, the structure of the data is called nesting. MLM accounts for nesting unlike linear regression models: “Quantifying the amount of unexplained variability at the different levels can be of interest in its own right, and sometimes multilevel models without explanatory variables are used to see how much the higher-level membership matters” (Rabe-Hesketh & Skrondal, 2012, p. 2). The higher-level membership in my study was the institution, so MLM will enable me to determine how much institutions influence AP outcomes. I utilized STATA to conduct

my analysis. Students were level 1 (L1) and were nested within institutions as level 2 (L2). I examined increase in model fit ability each time I add components, working toward the following MLM Logit models.

Independent Variables and Models

Independent variables for both models included mean center student first semester GPA (cwc_fgpa; student first term GPA – school mean GPA for that year), probation status, sex*ethnicity, transfer status (tran), faculty (cwc_fc; 1 – percentage of faculty matching student sex*ethnicity for first year) and student composition (cwc_sc; 1 – percentage of students matching student sex*ethnicity for first year), and AP policy criteria of the academic good standing GPA (gcut) and presence of any other criteria an institution used to put students on AP (ocut):

Retention by subsequent semester (ret) served as the outcome variable for RQ2:

Level 1: $ret_{ij} = \beta_{0j} + \beta_1 (cwc\_fgpa_{ij}) + \beta_2 (sex*ethnicity \text{ x } prob_{ij}) + \beta_3(tran_{ij}) + \varepsilon_{ij}$

Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01}(cwc\_fc_{ij}) + \gamma_{02}(cwc\_sc_{ij}) + \gamma_{03}(gcut_{ij}) + \gamma_{04}(ocut_{ij}) + \upsilon_{0j}$

$\beta_1 = \gamma_{10} + \upsilon_{1j}$

Graduation (grad) served as the outcome variable for RQ3:

Level 1: $grad_{ij} = \beta_{0j} + \beta_1 (cwc\_fgpa_{ij}) + \beta_2 (sex*ethnicity \text{ x } prob_{ij}) + \beta_3(tran_{ij}) + \varepsilon_{ij}$

Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01}(cwc\_fc_{ij}) + \gamma_{02}(cwc\_sc_{ij}) + \gamma_{03}(\text{gcut}_{ij}) + \gamma_{04}(\text{ocut}_{ij}) + \upsilon_{0j}$

$\beta_1 = \gamma_{10} + \upsilon_{1j}$

I avoided making causal claims and instead focus on developing an understanding of institutional variables associated with increasing or decreasing equitable outcomes of retention and graduation. Students were not randomly selected to be put on probation nor were policies consistent enough across institutions to conduct a quasi-causal study such as regression discontinuity. Instead of performing a randomized control trial or quasi-

causal study to make a strong causal claim, my questions were instead focused on how institutions might examine trends in EEVT's developmental factors, controlling for student factors.

Missing Data

Because less than 10.0% of data contain missing data, I removed observations through listwise deletion. I reported the number of first year engineering students who had enough terms in the database to be included with regards to graduation outcome. For example, some institutions have data in MIDFIELD from 2001 to 2018, so I only described students who entered engineering from 2001 to 2012 to allow for a six-year window for graduation. First-time, first year students who entered in 2013 would only have five semesters in the term table and would not have a comparable opportunity for graduation as students with six terms of data in the dataset. I removed 6 students who had already received a degree prior to the year of entry. These six students were spread out over five institutions, were both sexes, three ethnicities, and both transfer and first-time first year students.

Results

For research question 1 (RQ1), I reported the percent of students engineering programs put on AP in their first semester. Of the 49,095 engineering undergraduates in the sample, institutions put 6,025 (12.27%) students on probation in their first semester. See Table 2. The interclass correlation (ICC) for probation was 0.1559, meaning that 15.59% of the variance of probation status in the first semester can be explained by knowing which institution the student attended.

Disaggregated by sex*ethnicity, some groups were underrepresented and some overrepresented. The most underrepresented female group was White females, composing 6.97% of students put on AP and 12.25% of students in the sample for a difference of 5.28%. The most overrepresented female group was Black females, composing 1.38% of students put on AP and 0.70% of students in the sample for a difference of 0.67%. The most underrepresented male group was Other/Unknown males, composing 2.85% of students put on AP and 3.81% of students in the sample for a difference of 0.95%. The most overrepresented male group was White males, composing 67.77% of students put on AP and 63.97% of students in the sample for a difference of 3.80%. Unlike the female group, there was a close second in overrepresentation in the male group, Black males. Black males composed 5.01% of students on probation and 2.09% of students in the sample for a difference of 2.92%.

For RQ1, I also reported inferential statistics to determine any significant

Table 2

Counts and Percent of Students MIDFIELD Engineering Programs Put on Academic Probation (2001-2018)

	On Probation		Total		
	n	%	n	%	Representation
All Students	6025	12.27%	49095	100.00%	
Female- Asian	45	0.75%	495	1.01%	-0.26%
Female- Black	83	1.38%	345	0.70%	0.67%
Female- Hispanic/Latinx	26	0.43%	369	0.75%	-0.32%
Female- International	51	0.85%	637	1.30%	-0.45%
Female- Other/Unknown	41	0.68%	460	0.94%	-0.26%
Female- White	420	6.97%	6016	12.25%	-5.28%
Male- Asian	291	4.83%	2125	4.33%	0.50%
Male- Black	302	5.01%	1025	2.09%	2.92%
Male- Hispanic/Latinx	204	3.39%	1400	2.85%	0.53%
Male- International	307	5.10%	2946	6.00%	-0.91%
Male- Other/Unknown	172	2.85%	1870	3.81%	-0.95%
Male- White	4083	67.77%	31407	63.97%	3.80%

difference in probability of being put on probation by sex and sex*ethnicity. Based on the marginal effects (dy/dx = -0.0514, p < .001), females are 5.14% less likely than males to be put on probation in their first semester in engineering. See Table 3 for the marginal effects of sex*ethnicity on probation status with Black females serving as the reference group.

Examining likelihood of an institution putting a student on probation by sex*ethnicity, clearly demonstrates greater inequity. Where females as a group were less likely to be put on probation, no female group was put on probation more than Black females. For example, institutions were 17% less likely to put Hispanic/Latinx or White females on probation. The only sex*ethnicity group institutions were significantly more likely to put on probation were Black males (dx/dy=0.054, p < .05) as compared to Black females.

For research question 2 (RQ2), I reported the percentages of students retained after their first semester. See Table 4. The ICC was 0.2137, meaning 21.37% of the

Table 3

*Conditional Marginal Effects of Logistic Regression of Sex*Ethnicity on Probation Status in First Semester among Engineering Students in MIDFIELD (2001-2018)*

Sex*Ethnicity	dy/dx		Std. Err.
Female- Asian	-0.15	***	0.026
Female- Hispanic/Latinx	-0.17	***	0.027
Female- International	-0.16	***	0.025
Female- Other/Unknown	-0.15	***	0.027
Female- White	-0.17	***	0.023
Male- Asian	-0.10	***	0.024
Male- Black	0.054	*	0.027
Male- Hispanic/Latinx	-0.095	***	0.025
Male- International	-0.14	***	0.024
Male- Other/Unknown	-0.15	***	0.024
Male- White	-0.11	***	0.023

Note: *** = p < 0.001, ** = p < 0.01, * = p < 0.05

variance of retention from first semester to second semester could be explained by knowing which institution the student attended. This medium sized ICC justified the use of MLMs (Rabe-Hesketh & Skrondal, 2012). Then I designed an MLM by adding explanatory variables from EEVT. Each addition of independent variable resulted in a better fit model except for gcut and ocut, the probation policy variables. I measured if the new model was a better fit through chi-square statistics and a reduction of Akaike's Information Criteria (AIC), utilizing the Likelihood Ration Test (lrtest in STATA).

To determine which institutional or developmental factors significantly predicted whether an institution retained an engineering student from first semester to second semester, I ran a multilevel regression (melogit in STATA) with previously proposed variables. See Table 5 for conditional marginal effect values for each predictive factor of institutional retention. The difference between a student's sex*ethnicity and student composition was the only significant developmental predictor, controlling for the student

Table 4

*Counts and Percent of Students MIDFIELD Engineering Programs Not Retained or Retained by Sex*ethnicity (2001-2018)*

	Not Retained		Retained		Total	
	n	%	n	%	n	%
All Students	2662	5.42%	46433	94.58%	49,095	100.00%
Female- Asian	20	0.75%	475	1.02%	495	1.01%
Female- Black	16	0.60%	329	0.71%	345	0.70%
Female- Hispanic/Latinx	25	0.94%	344	0.74%	369	0.75%
Female- International	78	2.93%	559	1.20%	637	1.30%
Female- Other/Unknown	29	1.09%	431	0.93%	460	0.94%
Female- White	216	8.11%	5,800	12.49%	6016	12.25%
Male- Asian	76	2.85%	2,049	4.41%	2125	4.33%
Male- Black	80	3.01%	945	2.04%	1025	2.09%
Male- Hispanic/Latinx	82	3.08%	1,318	2.84%	1400	2.85%
Male- International	242	9.09%	2,704	5.82%	2946	6.00%
Male- Other/Unknown	122	4.58%	1748	3.76%	1870	3.81%
Male- White	1,676	62.96%	29,731	64.03%	31407	63.97%

Table 5

Conditional Marginal Effects of Logistic Regression: EEVT Factors on Retention from First to Second Semester among Engineering Students in MIDFIELD (2001-2018)

		dy/dx		Std.
	cwc_fgpa	0.04	***	0.011
	1.prob	0.00		0.0034
	Sex*Ethnicity			
	Female- Asian	-0.02		0.023
	Female- Hispanic/Latinx	-0.04		0.026
	Female- International	-0.13	**	0.039
	Female- Other/Unknown	-0.03		0.025
L1	Female- White	-0.01		0.018
	Male- Asian	0.00		0.018
	Male- Black	-0.03		0.023
	Male- Hispanic/Latinx	-0.02		0.022
	Male- International	-0.08	*	0.032
	Male- Other/Unknown	-0.04		0.025
	Male- White	0.01		0.025
	trans	-0.03	***	0.0071
	cwc_fc	0.00		0.0077
L2	cwc_sc	0.06	*	0.028
	gcut	-0.01		0.025
	ocut	0.00		0.0039

Note: *** = p < 0.001, ** = p < 0.01, * = p < 0.05

level factors. The difference from being at an engineering program where all a student's peers were similar to your group to an engineering program where all of your peers are different results in a 6% increase in likelihood of the institution retaining the student controlling for all other factors.

For research question 3 (RQ3), I reported the percentages of students an institution graduated in engineering. See Table 6. While White males were the only group overrepresented among engineering graduates (66.57% of the graduates as compared to 63.97% of the total sample for a difference of 2.60%), every other group was much closer to parity as compared to representation on probation. For example, International males

Table 6

*Counts and Percent of Students MIDFIELD Engineering Programs Graduated by Sex*ethnicity (2001-2018)*

	Not Graduated in Engineering		Graduated in Engineering		Total	
	n	%	n	%	n	%
All Students	28033	57.10%	21062	42.90%	49,095	100.00%
Female- Asian	286	1.02%	209	0.99%	495	1.01%
Female- Black	234	0.83%	111	0.53%	345	0.70%
Female- Hispanic/Latinx	226	0.81%	143	0.68%	369	0.75%
Female- International	398	1.42%	239	1.13%	637	1.30%
Female- Other/Unknown	275	0.98%	185	0.88%	460	0.94%
Female- White	3,494	12.46%	2,522	11.97%	6016	12.25%
Male- Asian	1,201	4.28%	924	4.39%	2125	4.33%
Male- Black	691	2.46%	334	1.59%	1025	2.09%
Male- Hispanic/Latinx	879	3.14%	521	2.47%	1400	2.85%
Male- International	1,855	6.62%	1,091	5.18%	2946	6.00%
Male- Other/Unknown	1109	3.96%	761	3.61%	1870	3.81%
Male- White	17,385	62.02%	14,022	66.57%	31407	63.97%

were the most underrepresented among engineering graduates, composing 5.18% of engineering graduates and 6.00% of the total sample, differing by 0.82%).

The ICC was 0.3066, meaning 30.66% of the variance of graduation in engineering could be explained by knowing which institution the student attended. Like RQ2, this medium sized ICC justified the use of MLMs. So I conducted a MLM by adding explanatory variables from EEVT. Each addition of an independent variable resulted in a better fit model except for ocut. See Table 7 for conditional marginal effect values for each independent variable on graduation in engineering.

The greatest conditional marginal effect was student composition, controlling for all other factors. For each subgroup of sex*ethnicity, controlling for other factors such as transfer status and first term GPA, the difference in likelihood of graduating from

engineering was decreased by 431% when comparing a school whose student body was completely like the individual student to a school entirely different. Similarly, with faculty composition, the less the faculty composition was similar to the student's, the less likely the institution would graduate that student. On the other hand, for each subgroup of sex*ethnicity, controlling for other factors, a one unit increase in academic good standing GPA standard increased the likelihood of graduating in engineering by 122%.

Discussion

While Braxton and colleague's retention model takes institutional context into

Table 7

Conditional Marginal Effects of Logistic Regression: EEVT Factors on Graduation from First to Second Semester among Engineering Students in MIDFIELD (2001-2018)

		dy/dx		Std. Err.
	cwc_fgpa	0.95	***	0.02
	1.prob	0.09	*	0.05
	Sex*Ethnicity			
	Female- Asian	0.48	**	0.19
	Female- Hispanic/Latinx	-0.18		0.20
	Female- International	-0.52	**	0.19
	Female- Other/Unknown	-0.53	**	0.21
	Female- White	-0.21		0.21
	Male- Asian	0.25		0.24
	Male- Black	0.15		0.27
	Male- Hispanic/Latinx	0.04		0.30
	Male- International	-1.06	***	0.33
	Male- Other/Unknown	-0.43		0.36
	Male- White	-2.65	***	0.42
L1	trans	-0.25	***	0.03
	cwc_fc	-0.85	***	0.08
	cwc_sc	-4.31	***	0.26
	gcut	1.22	***	0.27
L2	ocut	-0.01		0.04

Note: *** = p < 0.001, ** = p < 0.01, * = p < 0.05

consideration, many retention models such as Veenstra et al. (2009) and Tinto (1975, 1993) did not. My research study took environmental factors into account and argued for other scholars and engineering programs to examine factors associated with improved student outcomes. Institutional responsibility for engineering student retention and graduation has largely focused on remediating the student and focused on student level predictors for outcomes (Hamman, 2016). Through my critical lens, I followed the call to focus attention on institutional deficits associated with retention and graduation in engineering.

The results illuminate the need for more research and school level interventions to increase the likelihood all student groups are just as (and more) likely to graduate in engineering. In my results, both institutional factors were significantly predictive of graduation in engineering and only one was significant in retention from first semester to second. This means that future development of retention and graduation models should be aware that environmental factors may differ by outcome. Said more explicitly, how sex*ethnicity groups differed from the student population (student composition) was a factor which predicted the likelihood of both outcomes – institutional retention and graduation. This stood in contrast to how sex*ethnicity groups differed from the tenure and tenure track (T3) engineering faculty (faculty composition), which only significantly predicted how institutions graduated those student groups. Faculty composition did not significantly predict retention.

More research based on EEVT and Social Structural Theory is needed to examine how faculty composition matters in continued institutional retention past the first to second semester. One reason for this finding might be rooted in the continual choice a

student must make to persist toward graduation, a cycling back through the EEVT model. Time and again, minoritized student groups could get the messages that reiterate negative stereotypes about their identity with only a few voices available to refute them (Allport, 1954).

Second, cultural milieu constructs were empirically useful predictors in both retention and graduation models. These constructs should be considered in future retention and graduation models. Institutional context explained greater variation in the graduation outcome as compared to the retention outcome. This result combined with the finding that student and faculty composition were significant predictors of whether an institution would be likely to graduate a student in engineering highlights the need for more scholarship to consider institutional deficits. Lastly, there are key limitations to the archival data structure that might warrant improvement, such as how we capture race and ethnicity. This has implications for how we interpret the student level predictors such as international students. These results suggest engineering programs need to examine themselves as the deficit in retention and graduation outcomes.

The much less important finding was at the student level. This intersectional research delineated the nuance within educational outcomes (retention and graduation within engineering) by sex*ethnicity. We already knew from literature not specific to engineering that institutions were less likely to put females on probation. This finding held true for engineering. What prior research failed to be able to report was any nuance based on intersectionality. Namely, Black females in engineering were more likely to be put on probation. For retention and graduation likelihood among females, only International females were less likely to be retained and graduate from engineering.

Limitations and Strengths

One limitation of my study included aggregating Native American students and faculty into the Other/Unknown category, falling short of what Zhang et al. (2004) argued was a strength of a multi-institutional and longitudinal database. MIDFIELD needs to collect additional terms of data from existing participants to expand the student sample researchers can include in graduation outcome samples. Another limitation was this study did not examine suspension as an outcome of probation (Brawner et al., 2010; Burgess et al., 2000). Future research should examine who institution require to step away from studying engineering.

Because archived data analysis is limited by the data already collected, scholars suggested more careful considerations be made about the nature of categorical variables around sex and ethnicity (Connelly et al., 2016; Rankin & Garvey, 2015). How we structure these categories limits the way we can talk and expose inequitable power and minoritization of groups of students. These limitations should inform future development of the MIDFIELD expansion. Sociologists also suggested socio-economic status should be included in intersectional research (Bonilla-Silva, 1997). Lastly, scholars should examine other aspects of academic standing and outcomes, namely suspension. They should examine who voluntarily leaves by not returning from academic suspension and what institutional factors are associated with graduation.

Practice Implications and Conclusions

Institutions need funding and nationwide guidance to be self-reflective. Granting agencies such as the Howard Hughes Medical Institution (HHMI) whose purpose is to improve the outcomes for minoritized populations should issue calls for proposals which

focus on institutional deficits needing remediation. This call could include researched based interventions to increase minoritized enrollment in engineering as well as recruitment of talent to the professoriate. While programmatic efforts at the student level should and often have been one component of intervention, more effort must focus on dramatically shifting engineering student composition. HHMI projects, for example, have expanded proven, research-based programs to enable currently enrolled students to persist and take leadership roles within STEM disciplines.

The fact that institutional context explained variation in student outcomes also means that engineering programs could convene and share best practices based on those with the best and worse track records in graduating minoritized engineering students. Engineering educators and administrators should consider a workshop for Undergraduate Deans at the American Society for Engineering Education (ASEE), First Year Engineering Experience (FYEE), and Frontiers in Education (FIE) to look behind the curtain of anonymity which I, as a scholar, am required to shield institutional anonymity.

Appendix A

Engineering Faculty Composition by Sex and Ethnicity with Counts and Percent Among MIDFIELD Institutions (2001-2016)

	Female		Male		Full Sample	
	n	%	n	%	n	%
All Faculty	2396	11.81%	17896	88.19%	20292	100%
Asian	499	20.83%	3798	21.22%	4297	21.18%
Black	90	3.76%	298	1.67%	388	1.91%
Hispanic	67	2.80%	500	2.79%	567	2.79%
Other	47	1.96%	241	1.35%	288	1.42%
White	1693	70.66%	13059	72.97%	14752	72.70%

Source: American Society for Engineering Education Annual Survey

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MANUSCRIPT 3/SUSPENSION MLM

A National Study of Engineering Undergraduates Academically Suspended: Likeliness of Retention and Graduating at the Intersection of Sex and Ethnicity

Introduction

Most scholars have argued for increased efforts to retain undergraduate engineering talent based on the argument to position the United States as a strong global leader. Many contend that U.S. economic competitiveness depends on a strong engineering workforce which can lead the world in technology innovation and national security. Engineering undergraduate programs in the U.S. have not been satiating industry and governmental demand for engineering talent, particularly their call for a more diverse workforce (Association of Public and Land-grant Universities, 2018; National Academies of Sciences, 2007). Moreover, Engineering programs are not graduating their students who enroll: The American Society for Engineering Education (ASEE) regularly conducts an annual survey and publishes benchmarks in graduation rates and finds that significantly lower than the national 55% graduation rate, the four-year graduation rate for engineering schools was 33% (American Society for Engineering Education, 2016).

Scholars who argued for U.S. predominance through engineering talent missed the opportunity to interrogate which demographics engineering fields need to be truly innovative with, which is a more diverse workforce. ASEE's Department of Institutional Research and Analytics (2016) disaggregated this graduation outcome by ethnicity. On average for entering students from 2008 to 2013, there was a 17% gap between White and Black engineering undergraduates.

To address institutional financial instability and increase graduation rates, student departure research and models focused on the most prevalent type of departure – voluntary – within the first year (Braxton et al., 2013; Tinto, 1975). This is because institutions were eager to answer a central question – which departures can institutions influence to yield greater student retention? Voluntary departure was often paramount to involuntary departure as institutions were losing high achieving students who were likely to persist with institutional support. Tinto (2012) roughly estimated that "only 15 to 25 percent of all institutional departures arise because of academic failure" (p. 82). More research should examine Tinto's broad finding.

Involuntary departure through academic suspension (AS), has subtly been characterized as less important. Researchers typically characterized the student as the deficit through focusing on their poor study skills and habits (Tinto, 2012). Those who do study AS typically focus on student-level factors in predicting subsequent success only within the students who return (Brady, 2008; Cogan, 2011; McDermott, 2008; Suchan, 2016). Few studies examined AS policies and their components in terms of their outcomes and were conducted in the context of the community college setting (Meadows & Tharp, 1996; Rita, 1996). Only one study examined who does not return from AS and of those who return, who graduates (Goldman et al., 2003) and was not specific to engineering. Additionally, not returning after AS could arguably be another form of voluntary departure. Institutions and their policies excluded students they deemed to be deficient while failing to ask if they were effective in academically and socially integrating and engaging these students into the institution themselves. We lack any

findings to inform who institutions were best at retaining and graduating following AS, especially around minoritized populations in engineering (Brawner et al., 2010).

While the dominant narrative around student departure focused on first year voluntary student departure, it is important for researchers to consider utilizing a new research lens which heightens our awareness around any inequitable AS outcomes. A more nuanced narrative in literature included a finding that Black students and males are overrepresented on AS (Burgess et al., 2000). However, this report stopped short of quantifying the positive outcomes they reported in retention and graduation increasing, especially by sex and ethnicity. They failed to break down retention and graduation rates to inform who benefited most from policy changes. While we know which groups were academically suspended by institutions by sex and ethnicity separately, we lack a firm understanding through an intersectional analysis, namely by sex and ethnicity (sex*ethnicity).

Equity-minded researchers have implored investigating topics with a new critical and nuanced lens (Bensimon, 2018; Bensimon et al., 2019; Bonilla-Silva, 1997; Patton et al., 2015). Simply put, solutions can only address a problem research defines. My study aimed to examine AS as a color-blind practice with color-based inequitable outcomes. AS policies shift power from the student to the institution (Stone, 2012). We lack the literature to talk about AS in terms of its outcomes by sex*ethnicity, which is recommended by equity-minded scholars (Bonilla-Silva, 1997; Crenshaw, 1991; Else-Quest et al., 2010; Mitchell et al., 2014; Patton et al., 2015). While we know females are underrepresented on AS, we lack the understanding if this finding holds for non-majority females such as Asian, Black and Hispanic/Latina females.

Bensimon and colleagues also urged for a paradigm shift away from defining students as the deficit and toward examining our practices and policies:

> Let go of traditional schemata that paint student success as a matter of effort, motivation, self-regulation, goal commitment, or other student characteristics. These qualities are important, but focusing on them draws attention away from practices—influential factors that are within practitioners' control. Put simply, practitioners taking the traditional approach to student success may ask: What does this student lack and how can he/she be remediated? From an equity-minded standpoint, the primary question is: Why are our practices failing to produce success for students of color? (Bensimon, 2016, p. 4)

Based on Bensimon's reframing, I chose a theoretical motivational framework which included institutional variables which might explain institutional retention following AS instead of the traditional approach of focusing on student effort and motivation only among students who return after AS.

Problem Statement

The dominant narrative within retention research and models valued voluntary student departure and dismissed involuntary student departure. For example, research has intentionally excluded academically suspended students from retention studies. One study in the context of a private 4-year institution examined voluntary departure among its 1994 entering cohort and found that 8.5% of this class was academically suspended and chose to exclude those students from the study (McGrath & Braunstein, 1997). They chose to focus on the largest percentage of departure instead – voluntary – which constituted 30% of departure.

This dominant narrative is problematic when we know that minoritized populations are overrepresented among AS students. "Ideally, a performance standard might just 'weed out' those who have no chance at success and serve as a motivation for others" (Lindo et al., 2010, p. 114). The fact remains that institutions use student record data to exclude some to benefit others. The problem arises when institutions fail to examine who composes the “some” and “others.”

For those who researched undergraduate involuntary departure, the vast majority examined those who stopped out for the requisite period of time and returned to the same institution (Austin, 1992, 1992; Brady, 2008; Goldman et al., 2003; McDermott, 2008; Meadows & Tharp, 1996; Rita, 1996; Suchan, 2016). We need more research around who does not return - to the same major, the same institution, another institution or to higher education at all.

Research Question

To develop better retention models, we need more information about who engineering programs were best at retaining and graduating following AS. In other words, do we ‘weed out’ more of one group than another by excluding them from an institution? The following three research questions guide this study:

1. What percentage of students do engineering programs put on AS and does it differ across sex*ethnicity? (AS representation)
2. Is the likelihood of retention following AS in engineering associated with institutional factors? (AS retention outcome)
3. Is the likelihood of degree completion by AS status significantly associated with institutional factors? (AS graduation outcome)

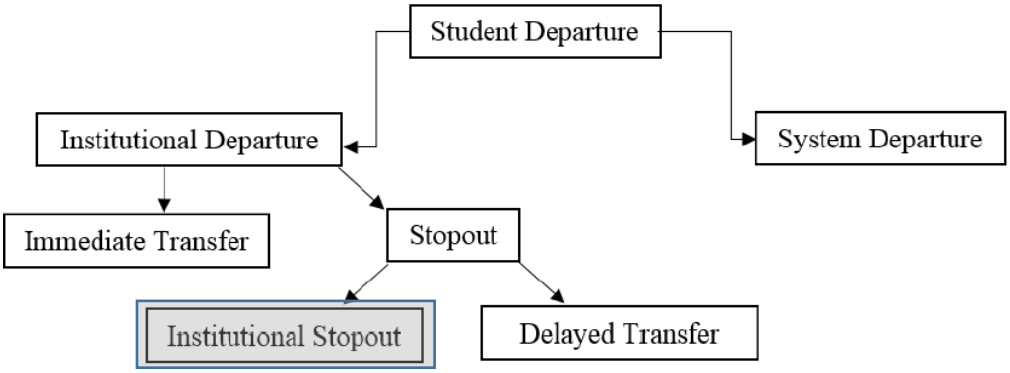
Departure Types and Key Terms

My research question was built on the student departure literature and it is helpful to clearly define the terminology used in this literature. To coalesce and provide common

terminology for departure literature, Tinto (2012) classified student departure as either an institutional departure or a system departure (see Figure 1). So in terms of AS, systems departure includes when a student is academically suspended and leaves higher education altogether. A student not returning from AS and just leaving their first institution would be an institutional departure, which could include immediate transfer or stopout. Immediate transfer would be if a student was academically suspended enrolled at another higher education institution. A stopout would include taking time away from an institution by delaying transfer to another institution or returning to the institution after time away. The time away could include a wide range (i.e. a semester to years). Many studies focused on the institutional stopouts (greyed in Figure 1). This framework provided my research a typology to discuss what gap in literature I filled and provided future researchers ideas on how to further delineate the types of departure following AS. My study examined departure and institutional stopout following AS. In other words, I only studied students who took a break and returned to the same institution.

Figure 1

Adaptation of Higher Education Student Departure Typology (Tinto, 2012)



Academic Suspension Terms

Academic policy terms included in my study were grade point average (GPA), academic good standing (AGS), grade point status (GPS), academic probation (AP), academic suspension (AS), academic expulsion (AE), and retention. GPA are averages of course level or term level grades, weighted by credit load of the course or term. The term, semester, or quarter GPA is an average across course grades for that unit of time. Beyond the actual mechanics of averages, I must stress the importance of understanding that grading at the course level serves as the basis for academic good standing, probation, suspension, and expulsion. Course grades compose the foundation which institutions build academic standing policies.

Brawner et al. (2010) defined academic good standing (AGS) as "a semester (SGPA) or cumulative grade point average (CGPA) that is high enough to avoid all academic penalties" (p. 8). Academic probation (AP) is one of the penalties incurred by not being in academic good standing, so one could say that academic probation is merely academic bad standing. Brawner et al. (2010) stated that students are placed on AP when a student has "an SGPA or CGPA that is lower than is required to be in academic good standing" (p. 8). During probation, unlike suspension, a student remains enrolled. Students returning from suspension may also be on probation until they meet the requirements of good standing.

Grade point status (GPS) was also used in AS literature to predict academic success for AS returners (Cogan, 2011). The method to calculate GPS depends on CGPA, AGS, and credits earned. For example, to calculate GPS for a student with a CGPA of 1.8 who earned 20 credits and an AGS of 2.0, subtract (AGS x credits earned) from (CGPA x

credits earned). So the student would have a GPS of (2.0*20) – (1.8*20) = -4. This negative number quantifies how much below the standard the student must make up after returning to be eligible to graduate.

It is important to note the impetus for academic probation. Most institutions have a 2.0 CGPA requirement for graduation (Brady, 2008; Brawner et al., 2010; Burgess et al., 2000). Within nine engineering institutions studied by Brawner and colleagues, all but one institution required a 2.0 for graduation. Georgia Tech held a standard of 1.95 for graduation from 1999-2003 (Brawner et al., 2010). In an effort to raise student awareness regarding this negative outcome, namely completing the coursework and not being able to graduate, institutions have warnings in place to alert students of potential downstream effects of their poor performance in any one term (Brawner et al., 2010; Burgess et al., 2000).

Academic suspension (AS) typically follows probation in a future term, only if a student fails to achieve AGS. Brawner et al. (2010) defined AS as a "requirement to separate from the university for a period of time, usually a semester or an academic year. Students may be suspended more than once" (p. 9). While academic expulsion (AE) was not a focus of my study, we must understand that not all institutions allow students to return after a single or multiple suspensions. Brawner et al. (2010) described AE as a "permanent separation from the university….[a student expelled] may not return except under extraordinary circumstances and only by appeal to a university committee or through other special programs" (p. 9). In other words, while some institutions hold fast to never allowing a student to return, some grant exceptions to the finality of a student's removal.

Study Importance and Rationale

Researchers and policy makers need to no longer dismiss the dismissed. Solutions cannot be developed until researchers start to ask questions about students who institutions do not retain following AS. For policy makers, student success practitioners, and most importantly, the students put on AS, this gap in research suggested that engineering programs might not be ready to look at who they are and are not best at retaining and graduating. Some engineering students do struggle and it is important for engineering programs to know who they are best at retaining following those struggles. We must make a commitment through research to value them and evaluate policies and practices, making space to talk about any difference in collegiate outcomes by sex, ethnicity, and sex*ethnicity.

Heightening attention to institutional deficits in no way negates the fact that some students need opportunities to develop skills and confidence. This is important and necessary work. However, narrowly focusing on remediating failing students is myopic at best. Policy makers, administrators, and Committees of Academic Standards need research which helps them also consider institutional factors influencing inequitable academic performance and return from AS by sex*ethnicity. We know little about who institutions fail to retain following AS and how their environments might impact their ability to attract students back from AS and eventually help students complete their engineering degree, narrowing any gap in graduation rates by sex*ethnicity.

Literature Review

I reviewed literature pertinent to 4-year institutions as they house engineering undergraduate programs. I searched for articles with important findings within academic standing policy literature and outcomes. I then detailed how preeminent research focused

on voluntary departure. Lastly, I provided a critique and methodological limitations of prior work, ending with my framework and equity lens to ground my analysis.

Academic Good Standing Increased Overtime

Institutions have utilized a wide variety of standards for AGS, ranging from 1.3 to 2.25 out of a 4.0 scale (Brawner et al., 2010; Burgess et al., 2000; Ebrahiminejad, 2019; Goldman et al., 2003; Lampe, 2020). Specific to engineering, Brawner et al. (2010) and Ebrahiminejad (2019) reported that institutions with engineering programs gradually increased their AGS standards. Most of the institutions with lower standards had increased them to 2.0 by 2005 with one institution increasing their standard to 2.25 by 2018. Goldman et al. (2003) reported that a single institution shifted from a 1.3 AGS standard for students who had earned less than 24 credits to a standard of 1.75 for those with less than 29 credits. Students at this institution were required to work toward a 2.0 standard after 122 credits and over time moved this standard earlier in an undergraduate's career to after completing 29 credits.

The tiered and gradual increase in AGS was also utilized by the Oklahoma Board of Regents for Higher Education across all their public institutions in the 1990s (Burgess et al., 2000). Over a three-year period, starting in 1990, Oklahoma public institutions increased their AGS standard from 1.6 to 1.7 for students below 30 hours attempted and reduced a three-tier system to two. In 1990, AGS standards were 1.8 between 31 and 60 hours attempted and then 2.0 after 60. By 1993, Regents required institutions to increase AGS standard to 2.0 after a student had attempted more than 30 hours. One 4-year Canadian institution with three campuses had an AGS standard of 1.5 for two of the campuses and 1.6 for the third (Lindo et al., 2010).

Academic Probation Persisters

My previous work laid the foundation for this section of the literature review, specifically the findings of likelihood of persistence following AP. In my previous publication, I found that AP did not equitably motivate academic performance by sex*ethnicity as measured by second SGPA (Lampe, 2020). Through a multilevel modeling regression across 19 institutions and including 133,147 students ever in engineering, I examined any significant interaction between sex*ethnicity and probation status. I found Black males (β = -0.05, p < .05), White females (β = -0.05, p < .05), and Other females (β = -0.24, p < 0.001) performed significantly lower in terms of their second SGPA on probation as compared to those not on probation. My study provided more nuance to the previous aggregate finding by Albert and Wozney (2018) which found that AP motivates most students to increase performance the following semester.

Not specific to engineering, Lindo et al. (2010) found males put on AP voluntarily drop out twice the rate as females put on AP. Lindo et al. also found weak evidence of academic recovery following AP for those who did persist, finding students on AP have an increase in probability of being put on AS. These pieces of work are important to understand in the context of studying AS because AP persisters form the subpopulation which institutions may put on AS. We must understand AP non-persisters to inform who engineering programs did not retain before ever persisting to the point where they would academically suspend that student.

AS Representation, Readmission, Return and Graduation Rate

In terms of aggregated AS representation, studies found institutions varied in suspension rates, ranging from 2%-10%. The University of Virginia (UVA) put 2.1% of

its students in engineering on AS from 2009 to Spring 2019 and the University of Colorado Boulder (UCB), 8.3%. More general than engineering, Burgess et al. (2000) reported Oklahoma higher education public, comprehensive institutions suspended 3.0% of its undergraduates. Goldman et al. (2003) found a single mid-sized, public, doctoral granting, research university suspended 10% of its first-year undergraduate population.

In terms of disaggregated AS representation by sex, studies across institutional types and over time found males were disproportionally placed on AS (Burgess et al., 2000; Goldman et al., 2003). Burgess et al. (2000) reported the peak suspension rate of males at comprehensive 4-year institutions was 8.6% as compared to 5.0% females in the 1993-1994 academic year, a 3.6 percentage point gap. Goldman et al. (2003) found a single institution put 13.8% of males on AS compared to 8.0% females, a 4.2 percentage point gap.

In terms of disaggregated AS representation by ethnicity, studies found Black students were disproportionally placed on AS (Burgess et al., 2000; Goldman et al., 2003). Burgess et al. (2000) reported the peak suspension rate of Black students at comprehensive 4-year institutions was 17.6% as compared to 6.3% White students in the 1993-1994 academic year, a 11.3 percentage point gap. Goldman et al. (2003) found a single institution placed 18.8% of Black students on AS compared to 8.2% White students, a 10.6 percentage point gap.

In terms of AS return rate, my previous work laid the foundation to understand AS return rate in the context of engineering undergraduates. Across two PWIs, first-time academically suspended engineers' (FASE) return rate to engineering ranged from 16.3% to 54.4%. Another study more general than engineering found 31.6% returned to the

university after suspension (Goldman et al., 2003). So, return rate from AS wildly varied by context and institution.

In my previous work, I examined return rates in the context of engineering more specifically by sex*ethnicity. I compared the difference between FASE student and returner composition. Among females, Black females were overrepresented among returners (2.2%) whereas other groups were closer to parity (i.e. Hispanic females overrepresented by 0.1%, Asian females and Other females met parity, and White females were overrepresented by 0.9%). Males tended to be further from parity. White and Asian males were underrepresented among returners (6.8% and 0.1% respectively). Other, Hispanic, and Black males were overrepresented (1.3%, 0.9%, and 1.6% respectively). Not specific to engineering, Goldman et al. (2003) reported that of the 222 Black students on AS, 77 (34.7%) returned as compared to the 31.6% aggregate return rate. They reported that of the 144 White students on AS, 144 (30.2%) returned.

In terms of graduation rates, in my previous work, I reported a 58.4% engineering graduation rate and 73.4% general graduation rate among FASE returners. It is important to note the two different denominators in graduation rates – out of AS students and out of AS returners. My first paper failed to report the graduation rate with all AS students in the denominator because we did not calculate the number of students on AS who had a 6-year window in our dataset. See Table 1. Goldman et al. (2003), however, did. Not specific to engineering, Goldman et al. (2003) reported out of the 221 returners, 43 (19.5%) graduated, composing 6.2% of all AS students. Phipps (1978) also reported that 7% of all AS students graduated.

Table 1

Total Enrollment, Suspended, FASE Return to Engineering Counts (Percentages) by Institution (Fall 2009-Spring 2010)

Institution	Enrolled	Suspended	Returned	Returned & Eligible	Graduate	Engineering Graduate
All	20043	1119 (5.6%)	256 (22.9%)	154	113 (73.4%)	90 (58.4%)
UCB	12563	1039 (8.3%)	169 (16.3%)	105	80 (76.2%)	74 (70.5%)
UVA	7480	160 (2.1%)	87 (54.4%)	49	33 (67.3%)	16 (32.6%)

Goldman et al. (2003) found no significant difference in graduate rates by sex (17.8% male and 20.8% female graduation rates). They also found no significant difference by race (24.7% Black and 16.7% White student graduation rates). Goldman and colleagues noted Black females had a higher graduation rate compared to Black males (28% and 15% respectively) without a statistical significance.

Summary of AS Outcome Research

In summary, we can build our knowledge off the few studies examining who institutions put on AS, who returns and who graduates. As a reminder, I focused my literature review to 4-year institution's AS outcomes as they house engineering programs. I found a scarcity of literature regarding AS policies and outcomes within 4-year institutions. From what was published, there were a number of findings specific and more general than engineering.

AGS standards increased over time toward a 2.0 (Brawner et al., 2010; Burgess et al., 2000; Ebrahiminejad, 2019; Goldman et al., 2003; Lampe, 2020). Males dropped out

at twice the rate as females put on AP (Lindo et al., 2010) and some populations by sex*ethnicity performed worse when placed on AP (Lampe, 2020).

Institutions placed students on AS with a range of 2%-10% (Goldman et al., 2003). Males and Black students were disproportionately put on AS (Burgess et al., 2000). By sex, percentage point gaps ranged from 3.6 to 4.2. By ethnicity between Black and White students, percentage point gaps ranged from 10.6 to 11.3. Institutions retained students after AS with a range of 16% to 54% (Goldman et al., 2003). Return rates by sex and ethnicity were closer to parity, based on those put on AS, with the exception of Black females being overrepresented among AS returners and White males underrepresented. In other words, the disproportionate rate of suspension was not further exacerbated by an inequitable rate of return, nor did return rates make up for the inequity of who institutions put on AS. Institutional graduation rates of students previously on AS ranged from 19% (Goldman et al., 2003) to 73.4%. Out of all AS students 6%-7% graduated (Goldman et al., 2003; Phipps, 1979).

Gap in Voluntary Departure Research

Over the last three decades, a plethora of higher education research addressed voluntary departure for good reason (Braxton et al., 2013; Seidman, 2012; Tinto, 2012). Researchers put considerable effort to develop empirically based models to understand the factors impacting a student's choice to persist to the second year. For example, Tinto (1975, 1993, 2012) found academic and social integration were pivotal factors for retaining students from their first to second years of college. Academic integration was operationalized and measured by semester grades, hours reported studying, learning and faculty interactions outside the classroom, peer conversations around academics, and

participating in honors programs and career development (Pascarella & Chapman, 1983). Social integration was operationalized and measured by frequency of weekends spent on campus, engagement in co-curricular activities, friend and romantic connections, and informal activities (Pascarella & Chapman, 1983). Braxton et al. (2013), however, did not find academic integration to be a significant factor in retention in the context of residential colleges and universities.

Less plentiful were empirically tested retention models within engineering. Veenstra et al. (2009) tested Tinto's model and empirically found academic integration was a significant factor in engineering first year retention. Veenstra et al. highlighted the need for more research to examine the high departure rate among students who leave engineering when their SGPA fell below 2.0, the AGS standard at the institution included in the study.

Many dissertations and articles examined what Tinto (2012) defined as institutional stopouts (Austin, 1992; Brady, 2008; McDermott, 2008; Meadows & Tharp, 1996; Suchan, 2016; Versalle, 2018). In terms of AS, these are students who returned to the same institution. Brady (2008) found factors were inconsistent in determining which AS returners would be successful. While prior predictive models are important to estimate the likelihood of successful persistence, they do not tend to measure institutional policies and thus avoid the conversation around any institutional or policy factors involved in AS return.

I would argue that failing to retain students following AS is a type of voluntary departure. This kind of voluntary departure has not been reflected in higher education retention models. One dissertation did examine the AS return process, reinstatement to

the university. Versalle (2018) examined the experience of AS students when the institution initiated the return process and provided programming for their return at one institution. There is a dearth of literature around reinstatement policies and how institutions retain students following AS.

Reinstatement – Institutional Role in AS Return

In my prior work, I suggested more research focus on reinstatement policies as there was a difference in how to count returners from one institution to another. Namely, UVA required its returners to reenroll in the same school whereas UCB allowed students to return and change schools and majors concurrently when returning from AS. UVA counted 87 (54%) of its 160 FASE students as engineering returners; whereas, UCB counted 169 (16%) as engineering returners of its 1039 FASE students. However, the higher 54% rate at UVA as compared to 16% at UCB may be inflated by the requirement that students reenroll in the Engineering School before they can transfer elsewhere. This example illustrates how AS figures can be misleading, depending upon idiosyncratic institutional policies. This study will look beyond the semester a students returns from AS to further understand an engineering program's likelihood of retaining students.

Limitations of Past Research

While I critique others for not disaggregating AS outcomes by sex*ethnicity, I demonstrated the difficulty of doing so within published research as the counts of AS students were small, ranging from 2%-10% among 4-year institutions. Even across two institutions over a ten-year span, I could not report graduation counts of AS returners by sex*ethnicity as each minoritized group had less than 10 students per my IRB protocol.

The main limitations of other AS research stemmed from lack of generalizability and limited disaggregation. For example, many studies were limited to one institution (Goldman et al., 2003; Lindo et al., 2010) or disaggregated by ethnicity by only using White and Black categories (Goldman et al., 2003). Methods included descriptive studies (Burgess et al., 2000; Phipps, 1979), as well as descriptive with chi-square analysis (Goldman et al., 2003) and quasi-causal analysis (Lindo et al., 2010). Datasets of these studies only included students who returned to the same institution and failed to address the different forms of leaving as defined by Tinto (2012).

Equity-minded Research Recommendations

Within quantitative research, equity-minded scholars have recommended using a critical lens to expose power used in oppressive practices and embedded in ways of thinking (Baez, 2007). Because AS literature repeatedly demonstrated a focus on the student as the deficit and regular use of "weeding out" language, I chose to critique the understanding of AS and examine its outcomes. The use of a policy to control a student's ability to persist toward completing a degree put power and judgement in the hands of the institution. As I look at institutions and engineering programs and their practices as the deficit, then it is possible that institutions more adequately intervened and motivated some students while demotivating others. My previous work demonstrated subsequent performance following AP was not positive for all sex*ethnicity groups (Lampe, 2020). While the practice of supporting a student to find motivation to pursue a degree outside of engineering is often a positive outcome, it may not be when inequitably dissuading minoritized populations from persisting toward a degree in which they originally expressed interest. I argue that, when academic probation with culturally competent

academic advising are at their best, it might lead to reduced reliance on academic suspension, which forcibly removes the student from their institution and potentially housing. When a student is so disconnected from resources, supports, and internal reflection which empowers them to make the decision to persist or take another course of action, that disconnection is yet another sign the institution fell short of fully integrating the student socially and academically.

While the policies themselves do not include ethnic or sex-based language, it is evident from existing literature that significant differences in outcomes exist for those students who institutions chose to put on AS. As a reminder, Burgess et al. (2000) and Goldman et al. (2003) reported Black students were disproportionally put on AS. While this study used archival data to examine trends and to begin examining which groups of students engineering programs were most likely to retain and graduate following academic suspension, future studies could collect academic and social integration data to learn more about what did or did not work for this population prior to academic suspension.

Criticize Source of Deficit

Among equity-minded researchers, there has also been a clear and vocal call for researchers to not solely focus on students as the deficit but to also think of institutions and policies as the deficit (Bensimon, 2018; Bonilla-Silva, 1997; Patton et al., 2015). For this reason, I chose to include institutional and policy variables to examine them as the source of deficit, asking why our policies are significantly failing some while helping others. Institutions regularly use student record data to find those they deem likely to not succeed at graduating, while not examining the outcomes of this judgement. For example,

Burgess et al. (2000) disaggregated by sex and ethnicity for those they put on AS but not by the outcome of increased retention and graduation rates. Simply put, studies failed to examine AS policies nor framed the analysis of the deficit around the environment of the institution. While my research was reductionist in terms of intersectional variables, I did examine institutions and policies as deficits, more studies must look across institutions and consider including institutional variables which influence student motivation.

Research Framework

To examine institutional factors, I chose a motivational framework – Eccles' Expectancy-Value Theory (EEVT) due to its many benefits. Eccles' (1983) motivational framework included environmental factors which might explain why female high school students were persisting less in advanced math courses as compared to their similarly achieving male counterparts. In addition to the benefits of institutional variables explaining retention, EEVT has also been tested over time and across multiple domains (Elliot et al., 2018; Wigfield et al., 2018). Lastly, Expectancy-Value Theory has been regularly utilized in engineering education research (Brown et al., 2015)**.**

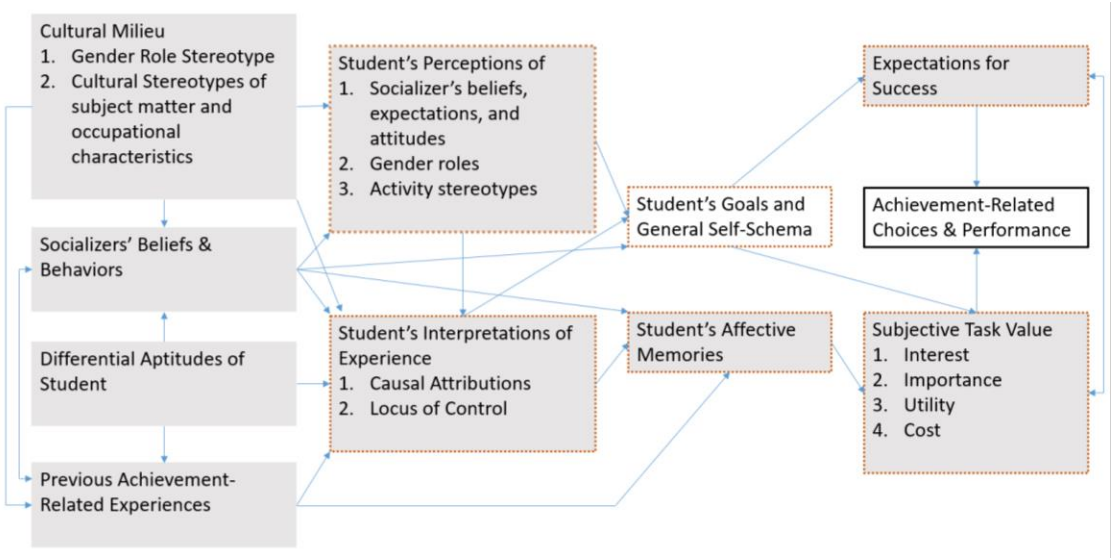
Controlling for past performance, females enrolled less frequently in advanced math courses than males. Through a complex array of factors, Eccles (2005) empirically tested multiple kinds of factors associated with persistence (see Figure 2). Bensimon et al. (2016) cautioned against focusing on the psychological responses of students – self-efficacy, goal commitment, and effort – and in line with other equity-minded scholars, insisted researchers focus on environmental or developmental factors. For this reason, I examined how the institutional culture and beliefs might impact an institution's ability to retain a student following AS.

Applied Concepts of Theory to Study

Within EEVT, I specifically examined how institutional factors of 1) cultural milieu and 2) socializers' beliefs, controlling for a student's past performance, were associated with the outcomes of retention and graduation following AS (see Figure 3). My rationale for using student composition was based on my previous work which showed that an institutions likelihood of retaining as well as graduating a sex*ethnicity student group within engineering was significantly associated with student composition. I further justify the use of these variables through Allport 's (1954) pinnacle work to explain human prejudice, aptly arguing exposure to minoritized perspectives reduced prejudice and stereotyping among majority populations. Else-Quest et al. (2010) found cultural milieu metrics were specific to a domain. Therefore, I measured engineering specific student enrollment. Unlike my previous work on academic probation, I was

Figure 2

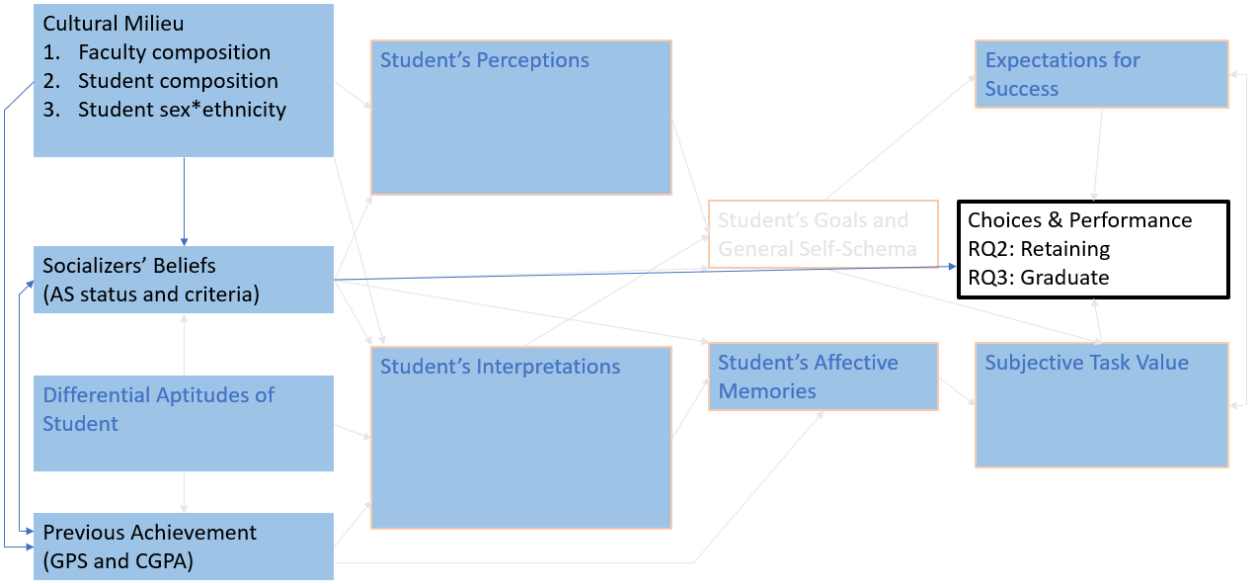
Eccles (2005) expectancy value model



Note: Psychological components outlined with dots and developmental components shaded grey.

Figure 3

Adaptation of Eccles (2005) Expectancy Value Model to Explain AS Policy association with Student Retention and Degree Completion following AS



unable to utilize faculty composition in this study as I needed to expand my dataset to include years not overlapped by the ASEE dataset which contained faculty composition. Similar to my prior work, I hypothesized that presence of greater diversity in terms of sex and ethnicity among the student and faculty population would reduce stereotypes and lead to the potential for better educational outcomes for minoritized groups in engineering.

For socializers' beliefs and behaviors, I included AS status and policy criteria. I measured previous achievement through CGPA and GPS at suspension. The outcome variable for research question 2 included the AS outcome of retention following AS and for research question 3 included the AS outcome of graduation within engineering. See the data dictionary (see Appendix A) for more details regarding the variables.

Methods

To answer the following questions, in this methods section, I described the sample, measurements, the archival data, and analysis process.

1. What percentage of students do engineering programs put on AS and does it differ across sex*ethnicity? (AS representation)
2. Is the likelihood of retention following suspension associated with institutional factors? (AS retention outcome)
3. Is the likelihood of degree completion by AS status significantly associated with institutional factors? (AS graduation outcome)

Sample

I used the same dataset in my previous study involving two Research I institutions for trends in academic probation over time and across multiple institutions. Due to the small percentage of students engineering programs put on AS, I needed to expand the years included in my sample in order to have a large enough sample size when disaggregating by sex*ethnicity.

Therefore, my data came from the Multi-Institutional Database for the Investigation of Engineering Longitudinal Development (MIDFIELD). MIDFIELD contains both student record data and university catalogs from 1988 to 2019. The university catalogs contained academic policies like AGS, AP, AS, and AE. The database as of March 2020 contained nine residential institutions who utilized academic suspension within the standing in MIDFIELD's term table. These nine institutions had 94,391 unique undergraduates who started in engineering with a 7-year window to graduate for first-time, first years and a 4-year window to graduate for transfer students. There were 9,665 students academically suspended at least once in engineering. The nine

institutions which used AS as an academic standing were included Clemson University, Embry Riddle Aeronautical University – Daytona Beach, Embry Riddle Aeronautical University –Prescott, North Carolina Agricultural and Technical State University, North Carolina State University, South Dakota School of Mines and Technology, University of Colorado, University of North Carolina Charlotte, and Virginia Polytechnic Institute and State University. See Appendix B for the proportion of the MIDFIELD sample that each institution comprised. Moving forward, each institution's student data will remain aggregated to fulfill MIDFIELD's data security agreement under IRB protocol. Data from these nine institutions varied in terms of years of data provided to MIDFIELD and the range in this sample spanned 1988 to 2013 admitted engineering students.

As previously explained, I utilized faculty composition (fc) by sex*ethnicity as a level 2 predictor in my study on academic probation; however, I needed to expand the sample by adding additional years as engineering programs academically suspend less students than they put on academic probation. Unfortunately, the ASEE annual survey data, spanning from Fall 2001 to 2018 only covered half of the MIDFIELD sample for this study.

Measures

I included the environmental variables available in MIDFIELD within the EEVT model (see Figure 3 for the adaptation). I used categorical and continuous independent variables from the MIDFIELD dataset to measure 1) cultural milieu, 2) socializers' beliefs, and 3) previous achievement, depending on the research question. To measure cultural milieu, I measured student composition (sc) as well as controlled for a student's sex and ethnicity. I created the sex*ethnicity variable by combining sex (male/female)

and ethnicity (Asian, Black, Hispanic/Latino, International, Native American, Other/Unknown, White) categorical variables. Black females served as my reference group based on equity minded researchers' suggestion to avoid remarginalizing the minoritized population (Else-Quest et al., 2010).

For socializers' beliefs, in my previous study, I was able to easily compare students in their first semester put on academic probation or not, while controlling for GPA cut off. Academic suspension was not so clean cut and I needed to include students across all levels. Therefore, my retention regression only involved students who institutions academically suspended. For the policy-based variable, I captured whether an institution suspended students who were above its required graduation standard, which was 2.0 for all the schools in my sample. This captured any institution who had additional criteria beyond the standard CGPA cut off. For previous student achievement, I utilized CGPA and GPS, mean centered within the graduation standard. I utilized transfer status to determine how many terms were needed to include the student in the sample, requiring a time-and-a-half window plus a year for graduation (seven years for first-time first years and four years for transfers). This window is important to note as past research has utilized the standard time-and-a-half window. I added a year to the time-and-a-half window since most institutions require the student to stopout for a year. I also used transfer status as a level 1 control variable.

Data Collection

Purdue University housed the MIDFIELD dataset and required an institutional IRB to be in place and confidentiality agreement signed to access the data. To collect the data, MIDFIELD administrators solicited interest from points of contact across the U.S.

and served as a centralized entity to archive student record data and university catalogs. Data include every degree-seeking undergraduate at participating institutions. This method, collecting all undergraduates and not specifically those enrolled in engineering, means researchers can report outcomes of students who started in engineering and subsequently leave. The database contains four tables with unique student identifiers to merge them together. The four tables are 1) student, 2) term, 3) course, and 4) graduate. Variable details within each table are located online (Long, 2018). See Appendix A for details of the variables I utilized in this study. The database also contains course catalogs which include academic policy information. The National Science Foundation funded the administration and research enterprise of MIDFIELD (NSF Award # 1545667).

Analysis

For AS representation (RQ1), my research design included descriptive statistics of counts, percentages and inferential statistics from logit regression. For AS outcomes (RQ2 and 3), I conducted a Multi-level Modeling (MLM) or Hierarchical Linear Regression analysis to determine the extent institutional variables explained the outcomes of retention and graduation within engineering. Each student (level 1) was situated within an institution (level 2), which is defined as nesting. Because nesting violates the ordinary regression model assumption of independence, I chose MLM to overcome this key limitation. I reported interclass correlations to justify the use of MLM, explaining how much of the dependent variable of retention and graduation could be explained by knowing which institution the student attended. In other words, I tested how much variance could be explained just by knowing which institution a student attended prior to adding EEVT explanatory variables. I cleaned the data and conducted the analysis within

STATA software. After each addition of EEVT independent variables, I reported the amount of additional variation these variables explained, working toward the following MLM Logit models.

RQ2 (AS retention outcome): Test whether CGPA or GPS is a better model fit for AS retention one and two semesters after AS, controlling for transfer status, and institutional variables of student composition and additional AS policy criteria.

RQ2 Model 1: Retention in Engineering Following Academic Suspension

Level 1: $ret_{ij} = \beta_{0j} + \beta_1 (cwc\_cgpa_{ij}) + \beta_2 (sex*ethnicity) + \beta_3(tran_{ij}) + \varepsilon_{ij}$
Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01}(cwc\_sc_{ij}) + \gamma_{02}(ocut_{ij}) + \upsilon_{0j}$
$\beta_1 = \gamma_{10} + \upsilon_{1j}$

RQ 2 Model 2: Retention in Engineering Following Academic Suspension

Level 1: $ret_{ij} = \beta_{0j} + \beta_1 (cwc\_gps_{ij}) + \beta_2 (sex*ethnicity) + \beta_3(tran_{ij}) + \varepsilon_{ij}$
Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01}(cwc\_sc_{ij}) + \gamma_{02}(ocut_{ij}) + \upsilon_{0j}$
$\beta_1 = \gamma_{10} + \upsilon_{1j}$

RQ2 Model 3: Retention in Engineering 2 Semesters After Academic Suspension

Level 1: $ret2_{ij} = \beta_{0j} + \beta_1 (cwc\_cgpa_{ij}) + \beta_2 (sex*ethnicity) + \beta_3(tran_{ij}) + \varepsilon_{ij}$
Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01}(cwc\_sc_{ij}) + \gamma_{02}(ocut_{ij}) + \upsilon_{0j}$
$\beta_1 = \gamma_{10} + \upsilon_{1j}$

RQ 2 Model 4: Retention in Engineering 2 Semesters After Academic Suspension

Level 1: $ret2_{ij} = \beta_{0j} + \beta_1 (cwc\_gps_{ij}) + \beta_2 (\text{sex*ethnicity}) + \beta_3(tran_{ij}) + \varepsilon_{ij}$
Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01}(cwc\_sc_{ij}) + \gamma_{02}(\text{ocut}_{ij}) + \upsilon_{0j}$
$\beta_1 = \gamma_{10} + \upsilon_{1j}$

RQ3 (AS graduation outcome): Test whether CGPA or GPS is a better model fit for AS graduation, controlling for transfer status, and institutional variables of student composition and AS policy criteria

RQ3 Model

Level 1: $grad_{ij} = \beta_{0j} + \beta_1$ (sex*ethnicity * $susp_{ij}$) $+ \beta_2(tran_{ij}) + \varepsilon_{ij}$
Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01}(cwc\_sc_{ij}) + \gamma_{02}(\text{ocut}_{ij}) + \upsilon_{0j}$
$\beta_1 = \gamma_{10} + \upsilon_{1j}$

For missing data, I removed observations through listwise deletion, as the only missing data were less than 10% of the sample. Because these models captured associations between variables, I refrained from making causal claims. These models best enable institutions to understand whether institutional factors played a role at retaining and graduating students in engineering. These models especially help administrators to reflect on who academic standing policies might be failing and who they help – or which students were weeded out with AS policies and at what juncture – suspension, retention or graduation.

Results

In this section, I provided data to help answer my three research questions around academic suspension – 1) representation, 2) return, and 3) graduation outcomes within engineering. For research question 1 (RQ1), as stated in the Methods section, there were 94,391 students who started in engineering and 9,665 (10.24%) academically suspended at least once within engineering in the sample. By sex*ethnicity, some groups were underrepresented and some overrepresented on suspension, comparing the percentage an institution 1) suspended by sex*ethnicity group within engineering to 2) percentage an institution enrolled in engineering in their entering class. Females were the most underrepresented sex group on academic suspension, composing 13.27% of students who institutions suspended as compared to the 18.28% institutions who initially enrolled in engineering. Therefore, females were underrepresented by 5.01%. While this percentage is encouraging as females represent to a group minoritized within engineering, this

underrepresentation did not hold for all females. Black, Asian and Hispanic females were overrepresented, by 0.40%, 0.18% and 0.14% respectively (see Table 2). For males, Black and Asian males were most overrepresented by 4.81% and 2.16% respectively.

Additionally, to determine if these institutions were likely to academically suspend one or more sex*ethnicity group more than another, I ran a logistic regression for sex and then sex*ethnicity. The inferential statistics underscored the need to not only examine sex alone. Sex independent of ethnicity did not capture the nuance that sex*ethnicity does in case the descriptive table did not already illustrate this point. While females were 3.43% less likely than males to be academically suspended in engineering

Table 2

Counts and Percent of Students MIDFIELD Engineering Programs Academically Suspended and Enrolled (Student Entering 1987-2013)

	Suspended at Least Once		Total		
	n	%	n	%	
All Students	9665	10.24%	94391	100.00%	Representation
Female- Asian	108	1.12%	923	0.98%	0.14%
Female- Black	321	3.32%	2,762	2.93%	0.40%
Female- Hispanic/Latinx	71	0.73%	522	0.55%	0.18%
Female- International	84	0.87%	976	1.03%	-0.16%
Female- Other/Unknown	53	0.55%	580	0.61%	-0.07%
Female- White	646	6.68%	11,491	12.17%	-5.49%
Male- Asian	611	6.32%	3,932	4.17%	2.16%
Male- Black	1,050	10.86%	5,713	6.05%	4.81%
Male- Hispanic/Latinx	289	2.99%	1,941	2.06%	0.93%
Male- International	575	5.95%	4,755	5.04%	0.91%
Male- Other/Unknown	295	3.05%	2,602	2.76%	0.30%
Male- White	5,562	57.55%	58,194	61.65%	-4.10%

Table 3

*Conditional Marginal Effects of Logistic Regression of Sex*Ethnicity on Academic Suspension Status within Engineering in MIDFIELD (Student Entering 1987-2013)*

Sex*Ethnicity	dy/dx		Std. Err.
Female- Asian	0.00079		0.012
Female- Hispanic/Latinx	0.020		0.016
Female- International	-0.030	**	0.011
Female- Other/Unknown	-0.025		0.013
Female- White	-0.060	***	0.0065
Male- Asian	0.039	***	0.0084
Male- Black	0.068	***	0.0080
Male- Hispanic/Latinx	0.033	**	0.010
Male- International	0.0047		0.0077
Male- Other/Unknown	-0.0029		0.0087
Male- White	-0.021	**	0.0062

Note: *** = p < 0.001, ** = p < 0.01, * = p < 0.05

(dy/dx = -.0343, p < .001), this likelihood does not hold for all females. See Table 3 for the marginal effects of sex*ethnicity on academic suspension status with Black females serving as the reference group. Institutions were significantly less likely to put many of the female groups on academic suspension than Black females, namely Other/Unknown, International and White females. Institutions were significantly more likely to put Black (dy/dx = 0.068, p < 0.001), Asian (dy/dx = 0.039, p < 0.01), and Hispanic (dy/dx = 0.033, p < 0.01) males on academic suspension in engineering.

My next research question (RQ2) aimed to determine any institutional factors associated with an engineering program's likelihood of retaining a student following AS. I examined how institutional factors were related to retention in the engineering major one and two semesters out from suspension. I looked one and two semesters out as my previous work found that some institutions require students to return to the school they were suspended from before switching majors or schools within the university. Requiring students to stay

in engineering on record but potentially not in course enrollment did not capture the true nature of retention. Therefore, retention the next semester following suspension may be a better indicator of who engineering programs are best at retaining following suspension. See Table 4 and 5, for counts and percentages of students engineering programs retained following academic suspension one semester and two semesters after AS.

The ICC for retaining students the semester they returned from suspension was .1285, meaning 12.85% of the variance of retention could be explained by knowing which institution the student attended. The ICC for retaining students two semester after they returned from suspension was .1067, meaning 10.67% of the variance of retention could be explained by knowing which institution the student attended. These small sized ICCs still justified the use of MLMs (Rabe-Hesketh & Skrondal, 2012). Although no

Table 4

*Counts and Percent of Students MIDFIELD Engineering Programs Not Retained Following Academic Suspension by Sex*ethnicity (Students Entering 1987-2013)*

	Not Retained in Engineering Following Suspension		Total		
	n	%	n	%	
All Students	3336	34.52%	9665	100.00%	Representation
Female- Asian	30	0.90%	108	1.12%	-0.22%
Female- Black	89	2.67%	321	3.32%	-0.65%
Female- Hispanic/Latinx	26	0.78%	71	0.73%	0.04%
Female- International	45	1.35%	84	0.87%	0.48%
Female- Other/Unknown	19	0.57%	53	0.55%	0.02%
Female- White	206	6.18%	646	6.68%	-0.51%
Male- Asian	178	5.34%	611	6.32%	-0.99%
Male- Black	312	9.35%	1,050	10.86%	-1.51%
Male- Hispanic/Latinx	130	3.90%	289	2.99%	0.91%
Male- International	224	6.71%	575	5.95%	0.77%
Male- Other/Unknown	149	4.47%	295	3.05%	1.41%
Male- White	1,928	57.79%	5,562	57.55%	0.25%

Table 5

*Counts and Percent of Students MIDFIELD Engineering Programs Not Retained Two Semesters Following Academic Suspension by Sex*ethnicity (Students Entering 1987-2013)*

	Not Retained in Engineering Two Semesters After Suspension		Total		
	n	%	n	%	
All Students	4477	46.32%	9665	100.00%	Representation
Female- Asian	46	1.03%	108	1.12%	-0.09%
Female- Black	135	3.02%	321	3.32%	-0.31%
Female- Hispanic/Latinx	36	0.80%	71	0.73%	0.07%
Female- International	56	1.25%	84	0.87%	0.38%
Female- Other/Unknown	28	0.63%	53	0.55%	0.08%
Female- White	294	6.57%	646	6.68%	-0.12%
Male- Asian	245	5.47%	611	6.32%	-0.85%
Male- Black	416	9.29%	1,050	10.86%	-1.57%
Male- Hispanic/Latinx	167	3.73%	289	2.99%	0.74%
Male- International	296	6.61%	575	5.95%	0.66%
Male- Other/Unknown	183	4.09%	295	3.05%	1.04%
Male- White	2,575	57.52%	5,562	57.55%	-0.03%

hard-fast rule exists, researchers often use 0.10 to be high enough to warrant investigation through MLM. Then I designed an MLM by adding explanatory variables from EEVT. Each addition of independent variable did not always result in a better fit model for retention directly following academic suspension.

To determine improved fit, I utilized the Likelihood Ratio Test (lrtest in STATA) and examined the chi-square statistic and change in the Akaike's Information Criteria (AIC). For example, the addition of transfer status was not a better fit for Model 1 and 2 (chi2 > 0.05 and ΔAIC < 1.29).

To answer RQ2, I reported the average marginal effects of the MLM for retention just for students engineering programs academically suspended. See Table 6.

Table 6

Average Marginal Effects of Logit MLM for Retention within Engineering in MIDFIELD (Students Entering 1987-2013)

		Model							
		1		2		3		4	
		dy/dx	Std. Err.	dy/dx	Std. Err.	dy/dx	Std. Err.	dy/dx	Std. Err.
	cwc_cgpa OR gps	0.22***	0.018	0.0061***	0.00060	0.25***	0.013	0.0066***	0.00047
	Sex*Ethnicity								
	Female-Asian	0.036	0.05	0.026	0.047	0.031	0.053	0.021	0.049
	Female-Hispanic/Latinx	0.053	0.056	0.045	0.052	0.077	0.062	0.069	0.057
	Female-International	-0.094	0.055	-0.068	0.050	-0.073	0.06	-0.044	0.055
	Female-Other/Unknown	0.099	0.058	0.10	0.054	0.11	0.068	0.12	0.063
L1	Female-White	-0.0039	0.032	-0.0016	0.030	0.0019	0.033	0.0057	0.031
	Male- Asian	0.049	0.032	0.056	0.030	0.086	0.034	0.093**	0.031
	Male- Black	0.017	0.029	0.020	0.027	0.061	0.03	0.062*	0.028
	Male-Hispanic/Latinx	-0.0094	0.037	-0.010	0.034	0.022	0.04	0.02	0.037
	Male-International	0.0096	0.033	0.011	0.030	0.046	0.035	0.043	0.032
	Male- Other/Unknown	-0.01	0.037	-0.024	0.034	0.028	0.04	0.015	0.037
	Male- White	-0.023	0.028	-0.019	0.026	0.0035	0.028	0.0066	0.026
	trans	NA	NA	NA	NA	0.04	0.013	0.022	0.013
	cwc_sc	NA	NA	NA	NA	NA	NA	NA	NA
L2	ocut	0.12***	0.025	0.13***	0.024	NA	NA	0.07**	0.026

Note: *** = p < 0.001, ** = p < 0.01, * = p < 0.05, Model 1 & 2 outcome was retention in engineering following directly after AS with 1) cumulative GPA and 2) grade point status, Model 3 outcome was retention in engineering two semesters after AS with 3) cumulative GPA and 4) grade point status

For environmental factors, adding student composition to the model did not yield additional explanation of the retention outcome. Adding the variable which captured whether an institution academically suspended students above a 2.0 cumulative standard was found to yield additional explanation for retention and was significantly positively associated. In other words, institutions were more likely to retain students following AS when they suspended students above the standard 2.0 CGPA.

For RQ3, I reported the counts and percentages of students in engineering programs who did not graduate following academic suspension, following the trend of reporting the undesirable outcome as the previous tables. See Table 7. I also reported the interclass correlation (ICC) for the MLM logistic regression and provided the average marginal effects. The interclass correlation (ICC) for graduating all students who started in engineering was .0091. However, the ICC for graduating students who started in

Table 7

*Counts and Percent of Students MIDFIELD Engineering Programs Graduated Following Academic Suspension by Sex*ethnicity (Students Entering 1987-2013)*

	Suspended and Not Graduated		Total Suspended		
	n	%	n	%	
All Students	7790	80.60%	9665	100.00%	Representation
Female- Asian	87	1.12%	108	1.12%	0.00%
Female- Black	267	3.43%	321	3.32%	0.11%
Female- Hispanic/Latinx	57	0.73%	71	0.73%	0.00%
Female- International	75	0.96%	84	0.87%	0.09%
Female- Other/Unknown	48	0.62%	53	0.55%	0.07%
Female- White	494	6.34%	646	6.68%	-0.34%
Male- Asian	484	6.21%	611	6.32%	-0.11%
Male- Black	864	11.09%	1,050	10.86%	0.23%
Male- Hispanic/Latinx	250	3.21%	289	2.99%	0.22%
Male- International	466	5.98%	575	5.95%	0.03%
Male- Other/Unknown	256	3.29%	295	3.05%	0.23%
Male- White	4,442	57.02%	5,562	57.55%	-0.53%

engineering and were suspended within engineering was .084. The difference in ICC might indicate that institutions in this dataset were similar in their graduation of their general student body; however, they differ in graduation rates for those they academically suspend. Based on the second ICC, I built the model using MLM even though the guideline most researchers use for conducting regression was 0.10.

Like my model design for RQ2, I added explanatory variables from the EEVT framework, and tested for added explanation of the outcome variable of graduating within engineering. All Likelihood Ratio Tests had chi-squared values well below 0.05 and reduced values of AICs. This included adding a random slope to the model based on sex*ethnicity. See Table 8 for average marginal effects.

Table 8

Average Marginal Effects of Logit MLM for Graduation within Engineering in MIDFIELD (Students Entering 1987-2013)

		dy/dx		Std. Err.
L1	susp	-1.75	***	0.028
	Sex*Ethnicity			
	Female- Asian	0.46	***	0.089
	Female- Hispanic/Latinx	0.265	*	0.11
	Female- International	0.35	***	0.093
	Female- Other/Unknown	0.021		0.11
	Female- White	0.20	**	0.06
	Male- Asian	0.51	***	0.068
	Male- Black	-0.19	**	0.067
	Male- Hispanic/Latinx	0.0078		0.081
	Male- International	0.24	**	0.077
	Male- Other/Unknown	0.045		0.085
	Male- White	-0.24	*	0.092
	trans	0.26	***	0.016
L2	cwc_sc	-0.92	***	0.078
	ocut	0.29	***	0.034

Note: *** = p < 0.001, ** = p < 0.01, * = p < 0.05

Like retention, engineering programs were more likely to graduate students when they academically suspended students above the 2.0 CGPA standard. Unlike retention, student composition was associated with graduation within engineering. Engineering programs were significantly less likely to graduate students in engineering who were most different from the student body, controlling for all other factors. Engineering programs were also significantly more likely to graduate most female groups than Black females (Asian 46%, Hispanic/Latina 27%, International 35%, and White females 20%). The only groups engineering programs were less likely to graduate were White and Black males, respectively 24% and 19% less likely.

Discussion

This study added to the understanding of how to describe and model academic suspension outcomes within engineering programs. Through a critical lens, my analysis and discussion focused on institutional responsibility and their deficits instead of solely examining failure at the student level, seeking to understand environmental factors associated with who an engineering program was best at graduating. I built off my previous work to examine not only retention in engineering directly following AS but also the second semester after. I answered important questions about not only who engineering programs academically suspend by the intersection of sex and ethnicity but also what environments or policies might be best to enable engineering programs to graduate students following academic suspension. Like Braxton and colleague's approach to developing new retention models, more and collective work will be needed to examine institutional level characteristics.

Probably the most important finding from the models was that student composition was negatively associated with graduation, controlling for all other variables. This means that engineering programs were significantly more likely to graduate a student if their student body most closely resembled the student's sex and ethnicity. Student composition was not significantly associated with engineering programs retention of students the semester or two semesters after academic suspension. Continued research, including qualitative and mixed methods, should examine why some institutional factors were important to graduation and not retention. For the other institutional level variable, it is good to know that institutions who academically suspended student above a 2.0 cumulative grade point average were more likely to retain and graduate students following academic suspension. This significant and positive likelihood aligned with the finding that engineering programs were more likely to retain academically suspended students with higher CGPAs.

The next important finding was the difference between retention directly following academic suspension and the second semester following. Of those suspended, 34.52% were not retained within engineering following AS and 46% were not retained the second semester following AS. This additional finding helps answer who engineering programs best retain following academic suspension more fully as some institutions require students to return to their school of enrollment before transferring out to another major. This work built off the finding that two universities who differed in reinstatement policies also differed in percentage who returned to engineering. Namely, the University of Virginia retained 54.4% in engineering following academic suspension with requiring

students to reenroll in the school who suspended them and the University of Colorado at Boulder 16.3% without such reinstatement policy.

My previous study lacked the percentage graduated among those who were academically suspended within engineering as I failed to limit the sample to those suspended with enough terms in the dataset. I only narrowed the dataset among those who returned from suspension. One previous study did capture the counts and percentages of students who graduated after academic suspension. Goldman et al.'s (2003) study found that 43 (6.15%) of the 699 students who were suspended graduated. I found that 1,875 (19.4%) of the 9,665 who were suspended graduated. This difference might suggest that future research could examine the difference in graduation rates of those suspended by academic field.

My previous work across two institutions found the engineering programs academically suspended 2.1% of engineering students at the University of Virginia and 8.3% at the University of Colorado at Boulder. In this study across nine institutions, I found engineering programs academically suspended 10.24%. In thinking about the kinds of departure described by Tinto (2012), this study also does not distinguish between students who never return from suspension and those who persist in the institution outside of engineering. It is also important to note that this study does not address who transfers out of engineering and earns a degree within the same institution. Within academic suspension research, future research could develop a more detailed departure model based on those academically suspended.

There is much work to be done to bolster datasets like MIDFIELD to more intentionally analyze suspension policies. First, I would recommend a thorough

examination of the use of the suspension variable across institutions who do not currently utilize academic suspension within the standing variable which captures academic standing like academic probation, warning and suspension. Through examining the policy documents, there are institutions who allow for multiple suspensions with little evidence that second suspensions are recorded in MIDFIELD. There are also institutions who have suspension policies and do not have any students academically suspended within MIDFIELD. This is one of the first research utilizing MIDFIELD's standing variable within the term table. Additionally, expanding the dataset to track students across institutions would help fill the research gap on institutional departure versus immediate or delayed transfer to another institution.

Future research should include a full paper examining the tiered academic standard policies versus the strict GPA cut off policies around academic good standing. Another paper and variable construction could focus on course forgiveness (also called repeat policies) before and after academic suspension. Currently no variable exists that captures whether a student utilized these policies. Another paper could focus on policies that include an automatic suspension without warning as compared to policies that utilize warnings and/or probation prior. And lastly, another paper could focus on reinstatement policies to create variables over time and across institutions that track whether a student must return to their school of enrollment when they return from academic suspension.

While this study mostly added to literature by taking the next step in describing and modeling return from academic suspension, much more work is needed to create a full model that includes a full array of variables to capture cultural milieu and socializers' beliefs. If three of the institutions who did not have enough terms in the dataset expanded

the term table, a future iteration of this could move on with adding in faculty composition captured in the ASEE Annual Survey, which only has data from 2001 to 2020. These three institutions term data ended in 2003 or 2004 and with additional terms provided there would be a more robust and ethnically diverse sample to conduct a MLM with faculty composition included as a factor.

Implications and Conclusions

Student success and diversity, equity and inclusion administrators are not interested in standalone retention models. They are interested in models which contain factors which explain associations with how their programs graduate engineers. While academic suspension numbers in most engineering programs were small, counts size should not indicate a lack of research importance. We should research how separating a student from their institution is associated with the likelihood an institution graduates the student with more consideration of environmental factors. This means that institutions need to collect more data on the kinds of environments they create in the classroom, through grading, and who composes policy decision makers and faculty makeup. Future database and survey collection should expand student and faculty gender variables beyond the binary and include sexual orientation (Rankin & Garvey, 2015), socio-economic status, and disability (Bonilla-Silva, 1997).

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Appendix A

Data Dictionary for Research Questions

Variable (name)	Data Type/Source	Research Question: Use
Cultural Milieu		
Student Composition (cwc_sc)	Continuous variable (percentage students enrolled by sex eth)/MIDFIELD	RQ2 & 3: Covariate
sex*ethnicity	12 binary variables	RQ1, 2, &3: Disaggregate by sex*ethnicity RQ2 & 3: Covariate of sex*ethnicity, Black females reference group
Sex (sex)	Male (0), Female (1)/MIDFIELD	
Ethnicity (race)	Asian, Black, Hispanic/Latino, International, Native American, Other/Unknown, White/MIDFIELD	
Socializers' Beliefs and Behaviors		
AS (susp)	Binary variable (0=no suspension, 1=suspension)/MIDFIELD	RQ1-3: Independent variable of interest
AS Criteria Other Criteria (ocut)	Binary (0=no added criteria, 1=additional criteria)/MIDFIELD Docs	RQ2 & 3: Covariates
Past Achievement		
Cumulative GPA (cgpa)	Continuous variable/MIDFIELD	RQ2: Covariate
Grade Point Status (GPS)	Continuous variable/MIDFIELD	RQ2: Covariate
Outcome Variables		
Retention Subsequent Semester (ret, ret2)	Binary variable (0=not retained, 1=retained)/MIDFIELD	RQ2: Outcome variable
Graduate (grad)	Binary (0=not graduated in engineering, 1=graduated in engineering)/MIDFIELD	RQ3: Outcome or dependent variable
Data Management Variables		

Transfer (trans)	Binary (0=first-time first year, 1=transfer)/MIDFIELD	RQ2: Covariate RQ3: Covariate & time-and-a-half plus 1 horizon graduate criteria
Major (cip6)	Six digit code classifying major to filter by engineering students (14xxxx-15xxxx)/MIDFIELD	RQ1-3: Sample criteria
Institution (institution)	Categorical Variable converted to unique id to merge with ASSE data/MIDFIELD	R2 & 3: Merging MIDFIELD and ASEE data, nested variable in MLM
Student (mcid)	Unique id identifying student/MIDFIELD	R1: Unique student counts R2 & 3: Merging MIDFIELD tables

Appendix B

Enrollment Count of Engineering Students by Institution with Sufficient Terms in the MIDFIELD Dataset to be Eligible to Graduate

Institution	Count	Percent
A	8,531	9.04%
B	9,911	10.50%
C	9,900	10.49%
D	2,817	2.98%
E	18,538	19.64%
F	15,161	16.06%
G	21,253	22.52%
H	4,187	4.44%
I	4,093	4.34%
Total	94,391	100%