Equitable Access to Majors through Removal of Competitive Application Process (CAPS) within a First-Year Engineering Program

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Introduction

Student interest plays a key role in motivation and persistence. Denying an undergraduate student entry into their first-choice major can have a profound effect on motivation to learn and persist to degree completion. Undeniably, student interest can change over time and majoring in something other than a student's initial interest at the time of university or college matriculation should be encouraged based on exploration and self-reflection. However, there are policies based on capacity limits in majors and constraints such as classroom capacity and course offerings that schools grapple with which exclude students from their interest. From literature, we know that about half of females interested in engineering actually enter the major they were initially interested in during their first year [1]. While there is some engineering education research which examines entry into engineering majors with regards to gender, there is a lack with regards to a student's ethnic identity. One reason to look at inequity by a student's identity with a minoritized group is based on a long history of higher education excluding minoritized groups and not crafting a welcoming environment or policies which take minoritization into account. Through the National Science Foundation (NSF), National Institutes of Health (NIH), Howard Hughes Medical Institute (HHMI) and other federal and non-profit grants, institutions have invested substantial money and institutional resources to correct and improve practices, policies, and pedagogy to increase inclusion of students from minoritized groups within engineering.

Programmatic efforts, such as outreach events and bridge programs aimed at improving sense of belonging and inclusion, are critical for improving equitable interest and access to engineering. While efforts are put into increasing interest in engineering, engineering programs should invest time to critically examine who their major declaration practices and policies exclude after a student is enrolled (i.e. post-matriculation). In other words, once institutions attract exceptional students to the field of engineering, they should examine who gets to pursue their primary interest and who is excluded. Many higher education researchers called for this kind of policy outcome analysis, especially examining policies which could lead to inequitable student experiences and outcomes and also highlighted institutions who are increasing equity in access and graduation rates [2], [3], [4], [5]. This call included a shift from seeing the student or the student's identity as the deficit or source of the problem that needs to be fix and instead called for dedicated time and shifts in power (i.e. school priorities and resources) to address policies which might exclude students in minoritized groups or create a chilly climate.

Thankfully, there is an already established data source where engineering programs can examine which student groups report not being able to major in their first-choice major. Within research universities who participate in the Student Experience in the Research University (SERU) Survey, one survey question asked students to self-report if they could not get into their first choice major. Within the United States, the universities awarding the highest number of engineering degrees were research university [6]. Based on research conducted by the American Society for Engineering Education Institutional Research and Analytics in 2022, Georgia

Institute of Technology, Purdue University, Texas A&M, University of Illinois at Urbana-Champaign, Arizona State University, University of Michigan, University of Central Florida, and University of California-Irvine graduated the most engineering undergraduates, more than 2,000 each. Therefore, research universities are a good place to start examining which student groups report a higher rate of not being able to declare the major they are most interested in.

Background

Based on the context of one undergraduate engineering program we studied, it is important to understand other environmental factors which were associated with student retention – matriculation models. Engineering education research provided definitions of matriculation models, which include First Year Engineering (FYE), Direct to Department (DtD), and Direct to University (DtU) [7]. An institution has an FYE program when they expect students to take courses not specific to a particular engineering field in their first year. The DtD expects students to start in their engineering major and often require them to start taking classes in that major directly upon matriculation. The DtU expects students to matriculate into the university without starting within a specific school or major. Within engineering matriculation models, research found students in FYE programs tend to make informed decisions and were less likely to switch majors when compared to their DtD peers [8]. Even within FYE programs, not all students experience the first year, namely external transfer students. Research showed that for community college transfers advising played a crucial role in clarity of major selection and persistence [9]. There is a dearth of research examining who was denied their first-choice major independent of engineering matriculation model. Past research focused on reducing switching through student choice without considering policies inhibiting choices.

In general higher education research, many researchers focused on student level factors of persistence. For example, a student's perceived fit with a major wass associated with their self-efficacy, and interest in a major or major fit was a determining factor in their persistence [10], [11]. Other researchers examined persistence factors at the student level such as in poor academic performance [12] or pre-matriculation opportunities to be exposed to engineering [13].

Because many have already examined student level factors in persistence, we want to shift the focus to an examination of how engineering school policies might have affected equity of major access, we posed an unconventional and critical question. To what extent does equity in major access exist at a Research I institution when accounting for shifts in policy such as removing a competitive application process?

Scope and Limitations

Our study is limited to one engineering school and includes a quantitative comparison of student-reported experience through a national survey across two survey cycles. Based on the limitation of one institution over two survey cycles, we recommended expanding generalizability in the future research section below. Also, due to using descriptive and inferential statistics, we do not claim causality of environmental factors on student outcomes. Future research could include quasi-causal research methods such as propensity score matching when randomized control experiments are not possible.

Methods

Institutional Context

The University of Virginia (UVA) is a mid-Atlantic, Research I and doctoral granting institution with about 17,000 undergraduates of which around 18% entered the university in the engineering school. Each year between 600 to 700 first-time, first year undergraduates matriculated directly into engineering as engineering undeclared majors. We described the ethnic makeup of the engineering students during the two survey periods examined in this study in Table 1.

Table 1. Count (%) of Engineering Undergraduate Enrollment by Ethnicity by Survey Year.

	African American	Asian	Hispanic	Multi-Race	Int'l	Unknown	White	Total
2018	125 (4.4%)	577 (20.5%)	167 (5.9%)	150 (5.3%)	101 (3.6%)	214 (7.6%)	1474 (52.4%)	2811 (100%)
2020	148 (5.1%)	688 (23.6%)	182 (6.2%)	170 (5.8%)	75 (2.6%)	197 (6.8%)	1454 (49.9%)	2914 (100%)

Note: Included ethnicities which aligned with SERU data. Source: University of Virginia Institutional Research & Analytics Enrollment Data accessed March 12, 2024

Engineering undergraduates took coursework in their first year which equally prepared them for the 11 engineering majors. In other words, the engineering program had a FYE matriculation model. This meant that the first year was a time where students could explore majors before declaring. The common coursework prepared them for any of the curriculum specific to an engineering major, which students typically started to take in their second year.

Prior to the 2016-2017 academic year, it was a common practice of the centralized engineering undergraduate office to provide a list of students to departments who ranked their major first, including academic performance based on first year grades. The departments would then admit students based on constraints like existing classroom space and teaching load. This paradigm was based on an understanding that the departments were constrained and not resourced to accept all students who wanted to major within that department. By extension, that meant the centralized office would work with departments to find a second or third choice major for students who were not accepted into their first choice.

In Fall 2016, the engineering dean's council and department chairs decided to eliminate their CAPS for majors, which meant that students declared and no longer applied to an engineering major. So each student was able to major in their first-choice major within the engineering school.

During this time period, the school also strategically invested in additional wrap-around student support. Before 2016, UVA's School of Engineering and Applied Science employed staff and had existing programming through their Center for Diversity in Engineering, Engineering Career Development, and embedded advising in their first-year engineering course. Researchers

found an increase in equity in student reported advising experience through the embedded advising model [14]. In 2016, the school had already embedded a student affairs professional who served on-call for the university and became the main point of outreach and contact for engineering undergraduate and graduate students needing holistic support. Researchers found that the addition of this position was associated with an increase in positive student outcomes and increased speed and frequency of support for engineering undergraduates [15]. In 2017, the school physically embedded counselors in the main engineering building and added an accessibility specialist in 2022. This expansion of resources should be considered an additional environmental factor in terms of retention of engineering undergraduates.

Research Questions and Data Sources

RQ1: Was there any statistical difference in outcome (equitable access to a student's first-choice engineering major) following a shift in an environmental factor (removal of CAPS by ethnicity and by gender)?

RQ2: Was there any difference in outcome (retention of first-time, first years to second year) following a shift in an environmental factor (removal of CAPS by ethnicity)?

To answer the first research question, we examined SERU survey question "were the following factors very important to you in deciding on your major?" The factor that the students responded to was "couldn't get in first choice major." The choices for this question were binary with a choice of yes or no. To ensure student privacy and reduce any risk or harm to students, IRB approval was obtained by UVA's Institutional Research and Assessment (IRA) staff - #IRB-SBS 3177 for the 2020 data and 2012008100 for the 2018 data.

To answer the second research question, we examined university data publicly available through the IRA dashboard. See the Appendix for detailed descriptive statistics of 1st year retention data for engineering undergraduates.

Survey and Statistical Analysis

The purpose of soliciting student responses through the Student Experience in the Research University (SERU) Survey is to generate new comprehensive longitudinal information on the undergraduate student experience. SERU data was used by university leaders, including engineering school deans, department chairs, other program directors, and researchers. Participating universities administer the survey every two years and the Center for Studies in Higher Education at the University of California-Berkley collect results for university benchmarking.

This engineering specific study was part of a larger request for school improvement to learn of inequitable student experiences based on minoritized group membership, particularly by gender and ethnicity. An Associate Dean in Engineering, leading diversity, equity and inclusion within the Dean's leadership council, played a key role in requesting disaggregated data to examine inequities. In 2021, working with the IRA office, they found statistical significance between groups with regards to ethnicity and not gender. Due to sample sizes, intersectional group memberships were not examined. We note this lack of intersectional analysis as examining

intersectional group membership (i.e. ethnically minoritized females) was recommended by researchers as a best practice, especially taking ethnicity, gender and socio-economic status into account [3].

An institutional research and analysis staff disaggregated institutional results from the SERU survey to narrow the sample from university-wide student responses to engineering undergraduate responses. They performed an analysis of variance (ANOVA) to examine any difference by group membership and reported p-values less than 0.1 and 0.01 according to recommended statistical significance [16], [17]. Student reported gender was a categorical variable - Male, Female, Trans Male/Trans Man, Trans Female/Trans Woman, Genderqueer/Gender Non-Conforming, Decline to state, Other, please specify_____. Student reported ethnicity was also a categorical variable - African American, Asian, Hispanic, Multi-Race, International, Unknown and White.

We then examined the aggregated engineering undergraduate first-year retention rate, specifically looking at the groups which differed significantly in equitable access to majors (i.e. African American, Asian and White student groups). We reported the difference in percentage of students by ethnic group and how each differed from aggregate retention percentages. We reported these percentages pre- and post-CAPS. First-time, first year engineering undergraduate admitted Fall 2009-2015 were included in pre-CAPS percentages and those admitted Fall 2016-2022 were post-CAPS.

Results and Discussion

The SERU results (see Table 2) yielded a statistical difference between groups of students who identified as African American, Asian and White within the 2018 survey. In 2018, significantly more African American students (31%) responded that they couldn't get into their first choice major when compared to Asian (3%) or White (4%) students. In the 2020 SERU survey results, that significant difference disappeared. We found no difference between males and females in the 2018 or the 2020 responses for this survey question.

Table 2. SERU Results: Mean and count of engineering undergraduates responding affirmatively that they could not get in their first-choice major in 2018 and 2020 SERU Survey.

	African American		Asian		Hispanic		Multi-Race		Int'l		Unknown		White	
Survey Year	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N
2018	0.31*	13	0.03*	96	0.19	21	0.05	19	0.13	8	0.11	27	0.04*	216
2020	0	16	0.03	91	0	19	0.08	25	0	9	0	29	0	202

*p<.01

Based on these SERU survey results, removing CAPS was associated with an increase in equitable access to majors, positively impacting all students and especially African American

students. We caution one interpretation of this data, using the findings to locate the blame at the student level. In other words, we do not agree with the interpretation that the students who identified as African Americans and did not get into their first-choice major should have tried harder and performed better. Similarly, we do not agree that students who were competitive based on their first two semesters of grades deserved their first-choice major.

From this logic based on self-interest, engineering deans and department chairs could defend CAPS to safeguard their faculty time, departmental resources, focusing on the top performing students and avoid needing to think about innovative practices to slightly expand classroom offerings and advising loads. Researchers noted this logic when examining institutions in the Netherlands, finding that dismissing students from a major due to their poor performance benefited those who remained in the major [18]. Our hope in explicitly stating this argument was that this logic stands in the way of truly seeing the potential for all entering students. We suggest engineering program policy decision-makers pause and examine environmental factors that inhibit groups of students based on the adverse cultural context some groups face to persist in engineering. We welcome the opportunity to explore perceived negative downstream effects and suggest continued research on equity in graduation rates and any change in school research funding.

To examine retention before and after CAPS, we conducted a preliminary review of the publicly available UVA IRA first year retention data (see Table 3). After CAPS were removed, there were relatively small differences between aggregated and disaggregated retention. Similar to equitable access, we found before 2016, the engineering program retained less African American students (95%) when compared to Asian (98.5%) or White (97.7%) students. After 2016, the retention difference by group is less. This preliminary review of the data only included reviewing descriptive data without inferential data to suggest improved research methods to account for additional environmental affects like the pandemic.

Table 3. Comparing UVA Engineering Total 1st Year Retention Rate Pre- (2009-2015) and Post-CAPS (2016-2022) to Retention Rate by Race/Ethnicity.

	Total	African American		Asian		White	
	Percent	Percent	Δ	Percent	Δ	Percent	Δ
Post-CAPS	96.7%	96.7%	-0.1%	97.7%	1.0%	96.6%	-0.1%
Pre-CAPS	97.6%	95.0%	-2.6%	98.5%	0.9%	97.7%	0.1%

For an equitable interpretation of this survey result, we quote Cathy O'Neil's admonition in her book *Weapons of Math Destruction* and point toward support rather than exclusion:

> 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. [19]

Research universities, most of which have highly selective admissions criteria, could choose to extend the practice of selectivity through CAPS. This would continue the practice of narrowing the population of students who enter their engineering fields and become faculty. Or instead, they can choose to empower the students they selected with the resources they need to pursue their interests.

The key players within this engineering program held leadership positions within the dean's council. The positions included faculty who were responsible for faculty affairs, undergraduate affairs, and as previously mentioned diversity, equity, and inclusion. They used both quantitative and qualitative data to increase awareness of inequitable access to engineering majors based on CAPS. First, they presented aggregate school data followed by disaggregated data by minoritized student groups. As awareness of inequity increased, there was still a tension of whose interest the school would prioritize, undergraduate education or research interest. Within research universities, department chairs and deans often must weigh priorities when resources such as faculty teaching time are at stake. There was a perceived trade off when considering removing CAPS as it meant that faculty teaching loads would increase and by extension time on research and subsequent funding could decrease.

Second, they organized a student forum, where African American students spoke of the impact CAPS for majors had on their undergraduate career. After department chairs heard directly from students, they decided CAPS needed to end under their leadership. To assess the outcome of this policy shift, these key player's successors partnered with institutional research and analytics staff to examine SERU data. Based on any findings, they continue to advocate for the continued practice of allowing students to declare their major and not apply through CAPS. The engineering leadership recommended a continual assessment of resources needed by department to address the perceived tradeoff of faculty teaching load. Resources could include increasing graduate teaching assistants to assist with grading and office hours and teaching focused faculty lines as well as increased access to classroom or design spaces.

Engineering Specific Student Support

As previously outlined in institutional context, expanded student support was another environmental factor during this time of improved retention. UVA Engineering invested in student support personnel which played a role in increased positive student outcomes [15]. In conjunction with removing policy barriers such as CAPS for engineering majors, the school decided to provide holistic support students need to be successful in learning and applying engineering content.

Future Research

Due to only including one institution and comparing across only two survey cycles in this study, we recommend an expansion to compare student experience across institutions and longitudinally for greater generalizability across engineering programs. Expanding the study across institutions increases the sample size and would allow researchers to examine intersectional identities (i.e. women of color), which is recommended by higher education researchers [2], [20]. Researchers could also use quasi-causal research methods to approximate

any causality between policy shifts and other environmental factors. Researchers should take care to describe other environmental factors such as matriculation models or additions in support resources contributing to increased equitable retention.

To expand generalizability internationally, the study could be replicated outside the United States. This would require the researchers to provide cultural context for minoritized groups within each country. For example, the Dutch higher education system instituted a dismissal policy that required students to leave certain majors due to poor performance and found that students remaining in those majors benefited the most [18]. Dutch institutions could examine any differential exclusion based on their historical knowledge of who is typically excluded from those majors or professions. In short, historical context and past practices matter in examining the interaction between exclusion and equity.

Lastly, we only examined the result of whether a student couldn't choose their first-choice major. We suggest a longitudinal study to look at the extent of equitable benefit to retention and graduation rates per major who previously had CAPS.

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Appendix A

Table 3. UVA Engineering Undergraduate First-time, First Year 1-Year Retention Rate by Admitted Year and Race/Ethnicity.

Admit Year	African American	Asian	Hispanic	Multi-Race	Int'l	Unknown	White	Total
2022	100.0%	97.2%	96.4%	97.0%	91.2%	100.0%	97.5%	97.4%
2021	94.6%	97.4%	100.0%	96.1%	90.9%	96.7%	98.9%	97.6%
2020	90.0%	96.8%	85.7%	100.0%	94.1%	95.0%	96.8%	95.7%
2019	96.9%	98.8%	97.8%	95.6%	90.0%	98.0%	96.1%	96.8%
2018	100.0%	95.8%	91.9%	97.4%	95.5%	100.0%	94.5%	95.5%
2017	95.0%	100.0%	92.1%	100.0%	94.4%	92.6%	96.9%	96.9%
2016	100.0%	97.5%	95.0%	96.6%	100.0%	98.3%	95.8%	96.7%
2015	95.2%	98.3%	100.0%	96.6%	92.0%	96.0%	96.1%	96.5%
2014	96.6%	99.0%	100.0%	100.0%	88.9%	93.3%	98.1%	97.9%
2013	96.2%	98.9%	100.0%	100.0%	95.7%	97.5%	98.5%	98.4%
2012	87.5%	98.9%	100.0%	100.0%	100.0%	97.1%	97.9%	98.0%
2011	96.0%	97.2%	90.9%	100.0%	96.8%	100.0%	98.0%	97.4%
2010	100.0%	97.9%	93.5%	90.5%	97.3%	96.4%	98.2%	97.6%
2009	93.3%	99.0%	94.1%	100.0%	92.3%	97.8%	97.2%	97.1%

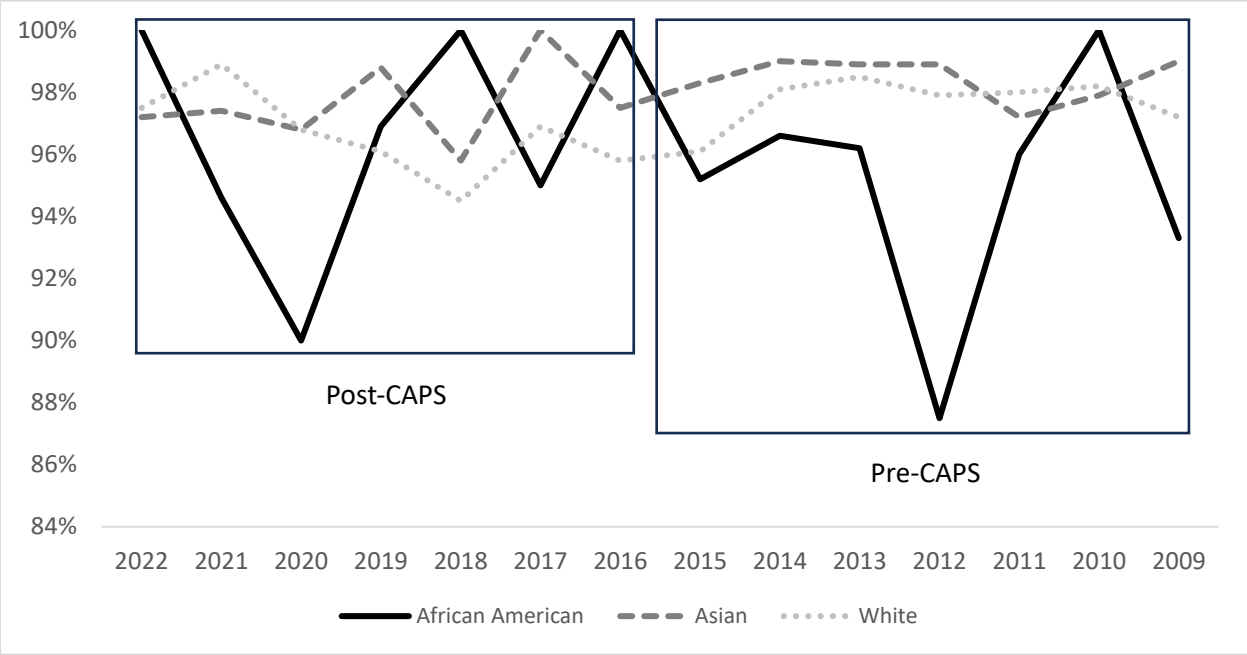

Figure 1. UVA Engineering First-time, First year 1-Year Retention Rate by Admitted Year and Ethnicity for Groups Significantly Different in Major Access. Source: University of Virginia Institutional Research & Analytics Retention Data accessed April 29, 2024.