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Vertical Transfer Student Pathways into Engineering: A 20-Year Benchmarking Analysis at a Large Public Research-intensive Institution in Florida

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ABSTRACT

Students who go to community colleges and then transfer to four-year universities to study engineering bring a diverse range of experiences and perspectives, which greatly contribute to the field of engineering and help national and regional workforce development. However, these students face specific challenges, referred to as the *vertical transfer penalty*, when they transfer to four-year universities. This can lead to lower completion rates for community college starters compared to students who start at four-year universities. The issue seems to be related to factors regarding the students' experiences, institutional characteristics, and geographic location. This study marks the initial stage of a comprehensive research project aiming to compare historical transfer student data over the past two decades at a large public research-intensive university in Florida. The study provides a longitudinal view of the academic pathways of the students who attended the university. This study looks at trends in student enrollment and degree attainment over time, accounting for various potentially confounding factors, such as race/ethnicity, gender, domestic versus international status, and initial community college attendance. We found that female transfer students were 1.7 times as likely to graduate with non-engineering degrees than male transfer students. In addition, we found that domestic students were 1.4 times as likely to leave without any degree and 1.8 times as likely to complete non-engineering degrees than international students. These findings have significant implications for future strategies and research initiatives to improve transfer student support and success across different regions.

1. INTRODUCTION

Over the past few decades, researchers and policymakers have outlined the critical need to broaden participation in engineering in order to meet the growing demand for engineering graduates in the engineering workforce [1], [2], [3]. Diversifying the engineering workforce is essential for fostering equity, innovation, and competition in the global market [4]. The National Academy of Engineering (NAE) has recently emphasized the urgent need to increase the participation of underrepresented groups, particularly women and racially minoritized individuals [5]. In higher education, vertical transfer students, who are disproportionately from underrepresented backgrounds, bring a wealth of knowledge, perspectives, and diversity to four-year institutions in ways that can facilitate new insights and enrich the field of engineering [6]. These students possess a unique "transfer student capital" that recognizes the value of their experiences and skills obtained from previous institutions [6]. This capital can offer considerable benefits for the engineering community and broader knowledge economy due to the provision of fresh and varied perspectives.

To better support transfer students, four-year institutions should prioritize tailored policies and practices that recognize their unique needs, potential for growth, and contextual experiences deemed crucial for a successful transfer experience [7] Given these dynamics, this research paper examines the experiences and outcomes of engineering transfer students over two decades at a large public research-intensive institution in Florida. In doing so, this study will identify and unpack the specific factors that help or hinder the successful integration of transfer students within a large research-intensive public university.

2. LITERATURE REVIEW

2.1 Importance of Transfer Students in Engineering. The transfer of community college students to four-year institutions to pursue engineering degrees is important for several reasons. Community colleges provide educational and vocational opportunities for students through technical education, academic transfer to four-year institutions, developmental coursework, continuing education, and community service [8]. Community colleges can play a crucial role in broadening participation in science, technology, engineering, and mathematics (STEM) fields, particularly for underrepresented groups, such as women and racially minoritized individuals [9]. Additionally, the National Science Foundation, as one example, has recognized that beginning engineering study at a two-year college before transferring to an engineering program at a four-year institution represents an important pathway to increasing access and attainment in engineering bachelor's degree programs [10].

The vertical transfer pathway is essential for the democratization of engineering bachelor's degree programs, as this pathway provides opportunities for students from diverse backgrounds to pursue engineering degrees [11]. Furthermore, community colleges offer the opportunity for students to complete the first two years of college, attain an associate degree, and then transfer to a four-year institution, which is particularly beneficial for individuals from lower-income backgrounds who can lower the cost of college attendance by starting at a community college [12], [13]. However, there are challenges that community college STEM students face when transferring to four-year institutions, such as a longer time-to-degree due to challenges with transferring credits between community colleges and four-year institutions [14]. To address these challenges, it is crucial to explore pedagogical practices that support non-traditional students in community colleges to persist in engineering and broader STEM majors and transfer to four-year colleges or universities [15], [16]. Additionally, efforts to increase interest and attainment in engineering and computer science by students at community colleges, especially women and underrepresented minorities, are similarly important to ease the transition from community colleges to universities [17]. This 20-year case study explores how community college students transition to engineering programs at a four-year institution in Florida. By delving into this area of inquiry, we aim to open doors for students from varied backgrounds and systematically identify and dismantle the challenges and barriers embedded within the vertical transfer pathway into engineering.

2.2. The Vertical Transfer Student Pathway into Engineering. Studies have shown that there are differences between students who transfer laterally and students who transfer vertically into engineering programs [18], [19], [20]. A lateral transfer occurs when students switch between institutions at the same level, such as transferring from one four-year college to another or from one community college to another. Our study will focus on vertical transfer students who move from a two-year engineering program to a four-year institution to earn their bachelor's degree. This pathway involves distinct challenges related to the *vertical transfer penalty*, which denotes the discrepancies in completion rates and academic hurdles encountered by community college students transferring to four-year institutions, compared to those who begin their postsecondary education at four-year universities [18]. Prior research has shown that students who transfer from a community college to a four-year institution are less likely to complete their bachelor's degree and take about three months longer to graduate than their peers who began at a four-year institution [21]. Research has also shown that transfer shock is more common in engineering transfer students who transfer vertically, indicating the difficulties they face in adjusting to the academic rigor and environment of the receiving institution [18]. Additionally, the lived experiences, institutional characteristics, and geographical location of vertical transfer students have been found to impact their transition and success in engineering programs [22], [23].

The demographic characteristics and educational outcomes of vertical transfer students, particularly women and underrepresented minorities, have been studied to inform debates regarding the efficacy of the vertical transfer pathway in engineering [24], [25]. With 38% of all U.S. undergraduates enrolled in community colleges [26] and a 12% projected enrollment growth by 2031 [27], the impact of vertical transfer students on the engineering discipline could be substantial. The National Center for Science and Engineering Statistics (NCSES) reports that 43.1% of STEM associate degree recipients were from underrepresented minority groups as of 2020 [28]. However, there is a notable decline in representation as the educational level advances, with only 26.1% of those obtaining STEM bachelor's degrees and 24.2% of those achieving STEM master's degrees being members of underrepresented minority populations [28]. Additionally, only 15.5% of students who began their journey at a community college in Fall 2015 attained a bachelor's degree within six years [29]. Even among those who transferred to a four-year institution after starting at a community college in Fall 2015, only 49.1% earned a bachelor's degree within six years [29]. This research highlights the critical transition from associate to bachelor's degrees as a strategic point for addressing the challenges and barriers that these students may face in their transfer process.

The challenges of the vertical transfer pathway into engineering are multifaceted but necessary to understand when seeking to better support the successful transition, retention, and completion of vertical transfer students. While students who begin their studies at a two-year college may have difficulties earning a four-year degree, the pathway from a two-year to a four-year institution remains a viable option for numerous engineering students. Studies have highlighted the importance of understanding the reasons for starting at a two-year college and the variation in experiences and outcomes across subpopulations, such as Hispanic students, on the vertical transfer pathway [22]. Many students reported affordability and proximity to home as the primary reasons for choosing to start at a two-year college [22]. Furthermore, the post-transfer transition experiences of vertical transfer students in engineering have revealed challenges related to the cost of attendance after arriving at the four-year institution, indicating the financial barriers these students face in four-year settings [23]. Additionally, pre-transfer programs have been identified as instrumental in improving the vertical transfer pathway in engineering through early integration programming and advising structures that help to streamline vertical transfer [30].

2.3. Challenges and Barriers for Vertical Transfer Students into Engineering. The challenges faced by transfer students in engineering programs can be addressed through a system-thinking approach, which deconstructs and tackles each interrelated component. Challenges associated with the vertical transfer pathway into engineering include academic preparedness and performance of undergraduates [31], articulation and transfer processes [18], [32], institutional commitment and collaboration [30], [33], and student diversity and subgroup variations [22].

However, limited research exists on the outcomes of engineering students who transfer via the vertical pathway [25]. Given the diversity among engineering programs and four-year institutions, it is valuable to examine how each institution's distinct environment and policies impact its population of engineering transfer students. Prior work has suggested that institutions should benchmark retention and success metrics of transfer students to offer insights into the long-term outcomes of support strategies and academic programs; however, previous studies have been unable to leverage rich administrative data covering numerous cohorts and focused specifically on the academic outcomes of vertical transfer students entering four-year engineering degree programs [34]. This study seeks to bridge this research gap specific to vertical transfer students and engineering degree programs, aiming to provide insights that can guide potential programs and policies geared toward enhancing vertical transfer student success within engineering.

2.4 The Role of Institution Type. Institution type significantly impacts the transfer student experience, influencing their academic and social integration, as well as their overall success. Transfer shock, marked by a decline in grade point average (GPA) at the receiving institution, is frequently observed among transfer students due to insufficient academic preparation and institutional support [18], [35]. The size and culture of the receiving institution can negatively affect transfer students, especially when transitioning from smaller institutions with a close student-instructor learning environment to larger research institutions that may not emphasize instruction in the same ways (i.e., R1 and R2) [36], [37]. For transfer students, the lack of personalized support and the absence of faculty involvement in policy development contribute to their struggles with engagement and adjustment [38], [39]. The social and academic experiences at the student's initial institution, as well as the experience of enrolling in the new institution, influence the retention rates of transfer students [40], [41]. Moreover, the type of initial institution, such as a community college, plays a crucial role in shaping the transfer student experience, affecting their academic achievement and satisfaction with various aspects of the university experience following their vertical transfer [7], [42].

The next section will summarize Florida's community college system, as the institution significantly influences transfer student experiences. It is crucial to understand the role of institution type to contextualize the challenges and opportunities faced by transfer students while navigating their academic journeys.

2.4.1 The Florida College System. In 2008, Florida's Senate Bill No. 1716 was enacted, which renamed the Florida Community College System as the Florida College System (FCS) to reflect its broader mission beyond traditional two-year programs [43], [44], [45]. The FCS has been addressing the evolving needs of the state's local workforces by offering a limited number of baccalaureate degree programs when there is considerable labor market demand and a shortage of high-demand bachelor's degree programs offered at the public four-year universities [46] Therefore, community colleges, including FCS institutions, are designed to provide access to high-quality, affordable academic and career-oriented programs that develop a competitive workforce and respond to diverse state and community needs [46], [47]. To achieve this, the FCS [48] has encouraged frontline staff to engage in data sharing and evidence-based practices, which has led to distributed leadership and collaborative decision-making across institutions in an effort to better understand the drivers of FCS students' experiences and outcomes [49].

The FCS comprises 28 colleges that offer a diverse range of academic and technical programs, including those related to engineering and technology. While several FCS institutions offer a small number of bachelor's degree programs, none of them provide engineering bachelor's degrees. A map of Florida, depicted in Figure 1, displays the locations of Florida's community colleges across the state's counties. As illustrated in Figure 1, Florida's community colleges are situated across different areas of the state. Furthermore, the map indicates the locations of the six R1 institutions in Florida, which are scattered throughout the state's various regions.

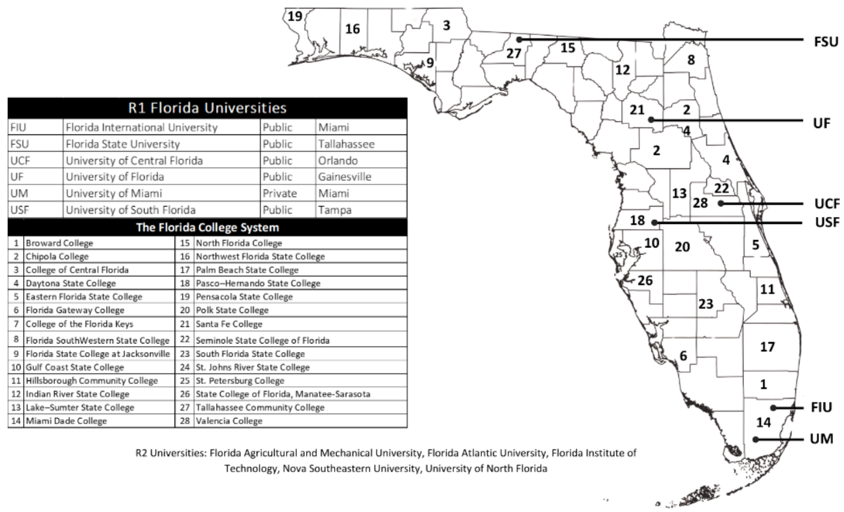

Figure 1. Map of Community Colleges (FCS) and R1 Institutions in Florida. The institutions are identified by their school acronym, while a number identifies the FCS. Map divisions represent counties in the state.

Florida's universities, particularly those with strong engineering programs, play a crucial role in educating and training engineers in the southeastern region [50], [51]. The state's commitment to engineering education is reflected in the development of pre-college engineering curricula, the establishment of specialized engineering facilities, and the implementation of programs aimed at bridging technical skills gaps between high school students and local employers [52]. Florida's universities, designated as R1 or R2 in Figure 1, exhibit varying degrees of research intensity. These universities typically have robust research programs across various engineering disciplines, such as materials science, power systems, and micro aerial vehicle aerodynamics [53], [54].

2.5. Benchmarking Student Success for Institutional Transformations. The importance of benchmarking student success for institutional transformations in higher education is a critical area of focus that has garnered significant attention in academic research. Benchmarking student success serves as a vital tool for assessing and enhancing institutional performance, accountability, and transparency, aligning with the broader goals of educational quality and effectiveness [55]. This emphasis on assessment and accountability has been underscored by various educational commissions, highlighting the relevance of engagement as an indicator of student and institutional performance [55]. Furthermore, benchmarking has been recognized as a strategy for achieving organizational transformation in higher education institutions, with the potential to offer numerous benefits and drive positive change [56], [57], [58]. Student success and retention continue to be of concern for higher education institutions, particularly in the context of wider participation combined with lower completion rates of nontraditional and historically underserved students. As a result, there is a need for new ways of understanding the student experience to ground policy and practice, making benchmarking an essential mechanism for understanding and addressing these challenges to improve institutional effectiveness in promoting student success [59]**,** [60].

Benchmarking student success for institutional transformations in engineering educational programs, with a particular focus on vertical transfer students, lies in understanding the impact of various factors on educational attainment. [61], [62], [63], [64], [65] The concept of educational attainment will be defined in this study as remaining enrolled in higher education and completing a degree [66], [67]. This achievement is influenced by various factors, including academic performance in coursework, social background, and the individual's personal circumstances [66], [68], [69]. Increasing diversity and degree attainment in engineering programs largely depends on the pursuit and attainment of bachelor’s degrees in engineering by underrepresented groups, such as Black and Hispanic students [73], [74], [75].

The research gap in studies on vertical transfer students in engineering is partly driven by the limited focus on understanding the specific factors influencing the experiences and outcomes of vertical transfer students in engineering programs. Although existing literature has studied the broad experiences and outcomes of transfer students in higher education [20], there is a critical need for more targeted research focusing specifically on the unique opportunities and outcomes of vertical transfer students in engineering disciplines. Additionally, there is a lack of literature on transfer student persistence after the first post-transfer year [76]. This study will leverage novel administrative data covering two decades of enrollment behaviors and outcomes in the state of Florida to directly address this gap in extant literature by offering a rich, detailed description of outcomes among vertical transfer students in engineering programs at a public research university.

3. METHODS

This study is the first phase of a larger research project that aims to investigate vertical transfer students’ experiences and outcomes upon transferring to four-year engineering degree programs. As a starting point, this paper will describe the benchmark enrollment and degree attainment metrics of vertical transfer students in engineering programs at the pseudonymized Sunshine University (SU), a large public research-intensive institution in Florida. To achieve this goal, the study will focus on answering the following research questions (RQ):

RQ 1. What trends can be observed in the enrollment of students transferring vertically to Sunshine University’s engineering programs over the last two decades?
RQ 2. What trends can be observed in the educational attainment of students transferring vertically to Sunshine University’s engineering programs over the last two decades?

Our research questions examine the complex interplay between student demographics, institutional characteristics, student enrollment, and educational attainment. In this study, we defined “educational attainment” in terms of three categories: those without a degree from SU, those who earned a non-engineering bachelor’s degree at SU, and those who earned an engineering bachelor’s degree at SU. Students who were still enrolled at SU at the time of the analysis but had not yet earned a degree were included in the “no degree” category. The goal of this case study is to explore the subsequent outcomes associated with the vertical transfer student process by initially focusing on enrollment trends and educational attainment over the last two decades. This study also aims to provide a starting point for future research and identify potential implications for supporting vertical transfer students in their pursuit of engineering degrees.

We selected a quantitative case study methodology as our research approach because it allows for an in-depth, comprehensive, and detailed examination of a specific problem [77]. In this paper, we report selected quantitative data collected to inform the case study research questions. While case studies are often associated with qualitative data, we plan to follow an explanatory sequential case study research design where we pursue a rich description of two decades of data to better understand the vertical transfer pathway into engineering degree programs [79]. By considering a rich data source of background characteristics, enrollment patterns, and student outcomes over two decades, this study also aims to contribute to the broader discourse on engineering education by investigating trends in vertical transfer student success at research-intensive institutions.

3.1 Study Context and Data Source. This study used two decades of data from SU, a large public research-intensive university in Florida. SU was chosen as the case study site due to its strong and diverse engineering program that attracts a high number of vertical transfer students. SU is a research-intensive (R1) university, and it has partnerships with two-year state colleges facilitating smoother transitions to engineering degrees. Its classification as an R1 institution—a designation for universities with the highest levels of research activity—signifies a vibrant academic environment conducive to innovative engineering education. SU's engineering program is a prime example within the region for its successful collaborations with many state colleges, which serve as feeder schools providing a steady influx of transfer students. These partnerships are structured through articulated agreements aimed to facilitate the transition for students pursuing engineering degrees, ensuring that credits earned at the two-year college level are recognized and applied toward their bachelor's degrees at SU.

3.2. Sample and Data Collection. The sample population for this study consisted of students who transferred vertically from one of Florida's community colleges into any engineering program at SU. Students were included based on administrative records from the institutional data archives. Before data collection, we obtained approval from the SU Institutional Review Board. All data were anonymized by staff at the college level to protect the privacy and confidentiality of the students involved in the study. SU provided detailed data, including demographics, academic characteristics, enrollment patterns, and educational attainment outcomes, for all engineering students since 2002. The research team performed data cleaning and analysis using Stata software. The data cleaning process primarily involved converting string variables into numeric variables for data analysis and checking for missingness among the variables. Additional variables were created to simplify some points of interest, such as bachelor's degree attainment in engineering.

The final dataset used in this study contained the following variables for each student: gender, race/ethnicity, international status, starting community college, enrollment year, exit year, and whether the student earned an SU degree. Based on the research questions for this study, the primary education outcomes of interest are (1) students who did not earn a degree from SU, (2) students who earned an engineering bachelor's degree from SU, and (3) students who earned a non-engineering bachelor's degree from SU. Additional educational outcomes are available; however, they are outside the scope of this study.

3.3 Data Analysis: Descriptive analysis will leverage detailed administrative data capturing characteristics and outcomes among engineering students who transferred vertically from a community college before enrolling at SU during any period between 2002 and 2022. However, for our degree attainment analysis, we focused on students who enrolled at SU between 2002 and 2019 to allow for enough time for vertical transfer students to graduate from SU. The dataset includes transfer students from all types of feeder institutions both inside and outside of Florida, including other four-year institutions and community colleges. However, we limited our study to students who transferred from community colleges within Florida. As noted previously, many of the community colleges included in our analysis offer four-year programs on a limited basis. However, none of the community colleges in our study offer four-year degree programs in engineering, so we consider all students transferring to engineering programs at SU from these colleges to be vertical transfer students. In total, for our degree attainment analysis, we analyzed

4,102 students enrolling between 2002 and 2019, and for our enrollment analysis, we analyzed 4,814 students enrolling between 2002 and 2022.

We made several key assumptions when cleaning the data due to the way SU collects institutional data. For example, there were three gender categories in the dataset: Male, Female, and "n," which we assumed to include any nonbinary response options. There were only nine students in the "n" category, so we excluded these students from the overall study. As another example, the racial/ethnicity categories were White, Asian, Black, Hispanic, Indigenous, Non-Resident, Pacific Islander, Unknown, and Multiracial. We found that the number of members in the Non-Resident group did not match the number of students identified as international students. Consequently, we excluded members of the Non-Resident group from the analysis because we were unsure of who was included in this group. Additionally, the populations of Indigenous, Pacific Islander, and Multiracial students were so small that we decided to analyze these populations together in a category labeled "Other."

We used descriptive statistical techniques to analyze the data collected. Since our study's goal is to provide a rich description of the characteristics and outcomes of vertical transfer students in engineering degree programs, [80] we focused specifically on descriptive statistical techniques. In this study, we explored enrollment outcomes across multiple characteristics of vertical transfer students, including race, gender, international status, starting community college, and year of enrollment. After describing enrollment patterns across subgroups, we then focused on educational attainment outcomes. We focused on three educational attainment outcomes in this study: earning no degree, earning a non-engineering bachelor's degree, and earning an engineering bachelor's degree. Like enrollment outcomes, we calculated the percentage of students in each attainment category through the lens of different characteristics of interest, including number of years spent at SU, race, gender, international status, starting community college, and year of exit.

4. LIMITATIONS

We conducted a study examining the demographics of engineering transfer students at a large public research-intensive institution for over 20 years. Although all students had information regarding their degree attainment and starting community college, some lacked information about their race or international status. Additionally, 10.4% of the sample is missing a starting cohort, which impacts demographic breakdowns when considering cohort year alone. Despite this, we proceeded with our analysis but acknowledged that our findings may be incomplete due to some missing data. Furthermore, we lacked information about student actions pre-transfer or post-SU. To estimate the duration each student spent earning a bachelor's degree, we assumed a standard attendance of two years at their starting community college. We understand that this may not be the case for all students in the study, but it is a likely proxy given national trends for vertical transfer students. Additionally, we did not have information on what happened to students who left SU without a degree. Some students may have transferred to another institution and earned a bachelor's degree elsewhere, but we do not have National Student Clearinghouse data to allow for these types of follow-up analyses. Moreover, we excluded some students from the racial/ethnic and gender analysis. We excluded students in the Non-Resident subpopulation from the racial/ethnic analysis because their number did not match the number of international students. We excluded nonbinary students from the gender analysis due to the small sample size, with only nine students across two decades of data.

We also note that our data do not include all racial, ethnic, and gender identities due to data limitations, which limits our ability to fully capture the outcomes across subgroups. While we use the term “Hispanic” in our race/ethnicity analysis, we acknowledge the nuances in the identities of people with Latin American ancestry and understand that this may limit our analysis [81]. Despite these limitations, which highlight the need for comprehensive data collection and analyses, our study offers a benchmark from which future research can build while providing valuable insights into engineering transfer student demographics and outcomes.

5. RESULTS

Guided by our research questions, this study describes many enrollment and educational achievement outcomes among vertical transfer students. Each student attended a public community college in Florida before transferring to SU and enrolled at SU between 2002 and 2022. Our findings are explored in depth in this section.

5.1 A 20-Year Analysis of Engineering Enrollment Trends. The following section will discuss the enrollment outcomes of SU engineering vertical transfer students over the last two decades. In total, 4,814 vertical transfer students were included in the enrollment analyses.

5.1.1 Enrollment trends by race/ethnicity. The racial demographics of all vertical transfer students enrolling in SU engineering programs between 2002 and 2022 are shown in Figure 2. Due to the missing data outlined in the limitation section, the sample size for this section of analysis was 4,568. As shown in Figure 2, while White students held a majority, Hispanic students were a substantial subpopulation, comprising 28.9% of all engineering vertical transfer students. Defining underrepresented minorities as the Black, Hispanic, and Other populations, the engineering vertical transfer student population from 2002-2022 was 36% underrepresented minorities. This is higher than the overall percentage (33%) of underrepresented minorities reported by the SU College of Engineering for Fall 2019. Consequently, the vertical transfer student pathway can be a strategy to improve the racial/ethnic diversity of SU engineering students.

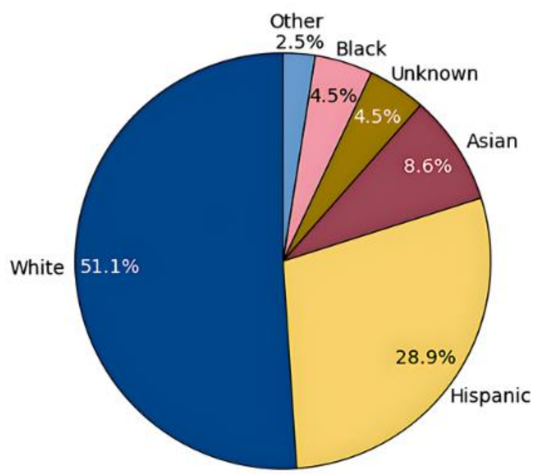

Figure 2. The racial demographics of the SU Engineering Transfer Student Population from 2002-2022, n=4,568. Non-resident students were excluded from this analysis.

In addition to examining the overall enrollment from 2002 to 2022, we examined the yearly trends of the racial demographics of the vertical transfer student population from 2002 to 2022, as shown in Figure 3. The engineering vertical transfer student population has grown more racially diverse over time. In particular, the population of Hispanic students has more than doubled. Additionally, Hispanic students constituted the largest racially minoritized group of the population for the very first time in 2022.

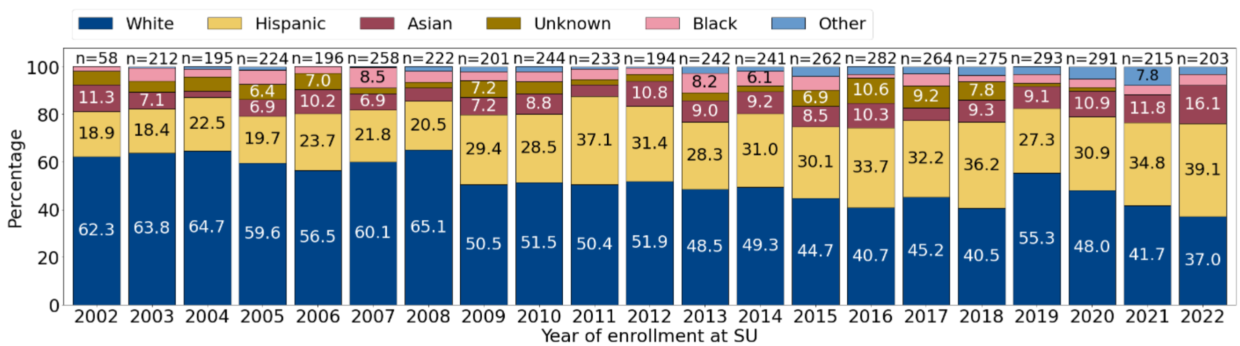

Figure 3. Racial/Ethnic Demographics of Engineering Vertical Transfer Students by Year of Enrollment

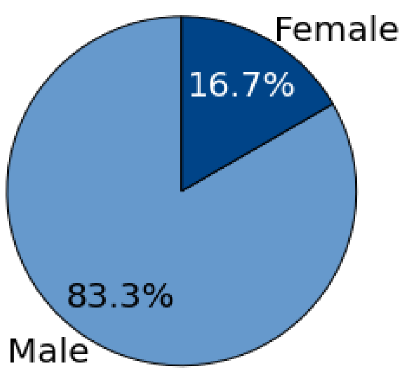

Figure 4. Gender Demographics of All Enrolled Engineering Vertical Transfer Students, n=4,805.

5.1.2 Enrollment trends by gender. Figure 4 shows the gender demographics of all engineering vertical transfer students entering SU from 2002 to 2022. After removing nine nonbinary students, the sample size for this section of the analysis is 4,805. Women constituted approximately 16.7% of the total engineering vertical transfer student population between 2002 and 2022, which is lower than the U.S. average, with 24.2% of engineering bachelor's degrees awarded to women in 2022 [82]. As reported by SU, the undergraduate engineering population at SU is 29% women, so the proportion of female vertical transfer students in engineering is lower than the overall undergraduate engineering population at SU.

In addition to analyzing the enrollment by gender of all students from 2002 to 2022, we also examined the gender demographics over time. Figure 5 below shows the yearly gender demographics of the engineering vertical transfer student population enrolling from 2002 to 2022.

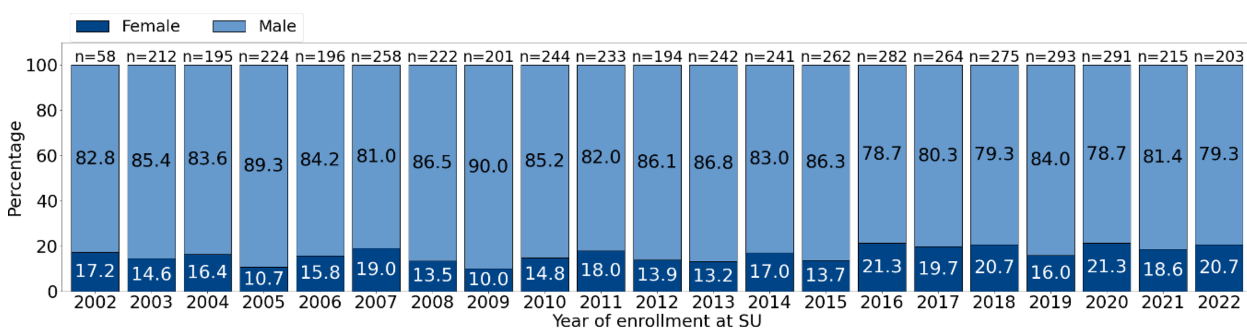

Figure 5. Gender Demographics of Engineering Vertical Transfer Students by Year of Enrollment

While the percentage of female engineering vertical transfer students has not increased substantially, the percentage of female vertical transfer students in recent years is higher than the percentage of female vertical transfer students in the beginning years of this study. However, as previously discussed, the percentage of female students among engineering vertical transfer students in this study is notably lower than the overall percentage of women in the US engineering undergraduate population [82].

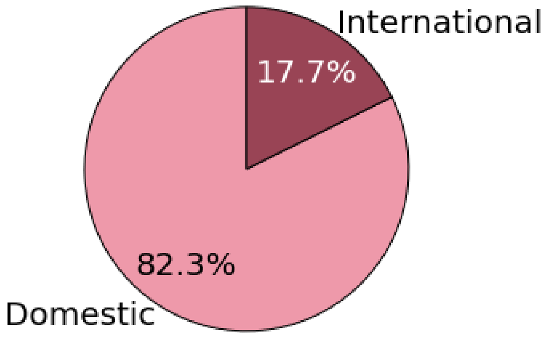

Figure 6. International Status Demographics of All Enrolled Engineering Vertical Transfer Students, n=4,755.

5.1.3 Enrollment trends by international status. Figure 6 shows the demographics of all enrolled engineering vertical transfer students based on international status.

International students comprised 17.7% of the engineering vertical transfer student population at SU from 2002-2022. This is a higher percentage of international students when compared to the U.S. population, where only 10.6% of engineering bachelor's degrees were awarded to international students in 2021 [82].

5.1.4 Enrollment trends by starting community college. While students transfer to SU from various institutions, in this study, we only included students who had previously attended one of Florida's 28 community colleges. Figure 7 shows the 20-year enrollment proportions at SU among the top three feeder community colleges, with all other community colleges combined into an "All others" category.

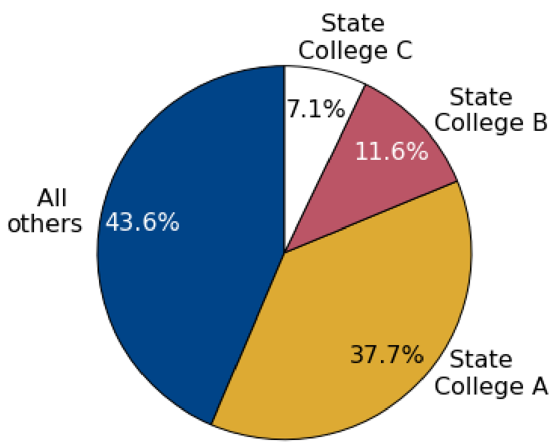

Figure 7. Percentage of All Enrolled Engineering Vertical Transfer Students from each state college, n=4,814.

Of all engineering transfer students entering SU from 2002-2022, 56% originated from pseudonymized State College A, State College B, and State College C, which were the three largest feeder community colleges. The remaining community colleges each contributed less than 5% of the total engineering vertical transfer student population at SU, so they were combined into a category called "All others." First, State College A, located in the same city as SU, reported a student population of about 13,000 for Fall 2022 [85]. State College A was the most common feeder community college, comprising 37.7% of all enrolled engineering vertical transfer students over the past 20 years. Second, State College B, a large educational institution located far from SU, reported a total student population of almost 50,000 students for Fall 2022 [85]. Despite being geographically distant from SU and lacking an engineering partnership with SU, 11.6% of students who transferred vertically to SU's engineering program came from State College B. Finally, State College C, located far from SU, reported a Fall 2022 student population of about 30,000 [85]. Students from State College C comprised 7.1% of all engineering vertical transfer students enrolling at SU over the past 20 years. Like State College B, State College C is a high-enrollment institution located far from SU without an articulated engineering partnership with SU.

5.2 A 20-Year Analysis of Engineering Educational Attainment Trends. While the previous section focused on engineering enrollment, the following section will discuss the educational attainment of SU engineering vertical transfer students over the last two decades. In total, 4,102 vertical transfer students were included in the educational attainment analyses.

5.2.1 Trends in overall degree attainment rate. Before analyzing the data through the lens of different subgroups, we explore degree attainment outcomes among the overall vertical transfer student population enrolling between 2002 and 2019.

Between 2002 and 2019, 17.8% of SU engineering vertical transfer students did not complete a degree at SU, with 77.1% completing an engineering degree and 5.1% completing a non-engineering degree (see Figure 8). A small, but not inconsequential, percentage of SU engineering vertical transfer students earned a non-engineering degree. While all students included in this study entered SU intending to major in engineering, we should not ignore those who switched to non-engineering degree programs. Future studies should explore student motivations to leave engineering and complete a degree in another discipline.

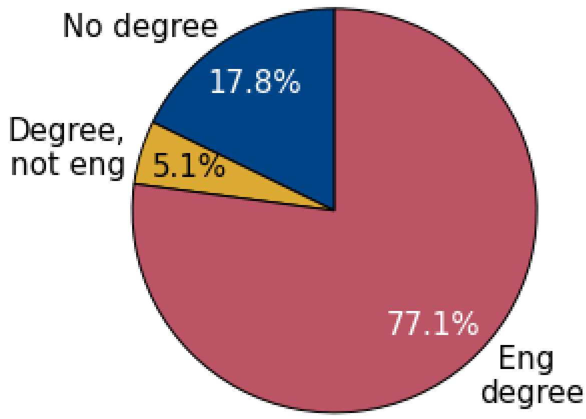

Figure 8. Overall Degree Attainment of Engineering Vertical Transfer Students from 2002-2019, n=4,102.

Figure 8 does not indicate the time a student took to complete their degree. To calculate the six-year bachelor's degree completion rate, we examined each student's degree status four years after their enrollment at SU, assuming two years at the initial community college before vertical transfer. If a vertical transfer student earned a degree in four or fewer years after arriving at SU, we included them in the six-year degree completion categories. If a student took more than four years to earn a degree at SU, we included them in the "No degree" category, given the specific focus on a six-year graduation window. Students who did not earn an SU degree at any point were also included in the "No degree" category. Figure 9 shows the results of this six-year graduation rate analysis. Within four years of SU enrollment (i.e., within six years of initial enrollment), 70.2% of students had earned an engineering bachelor's degree, and 4.3% had earned a non-engineering bachelor's degree. When comparing the six-year degree attainment to the overall degree attainment, we found that about 7.7% of all vertical transfer students will take more than four additional years to earn a bachelor's degree upon their arrival at SU.

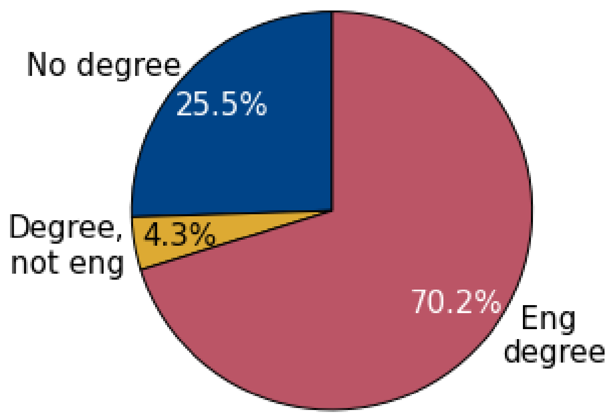

Figure 9. Six-year graduation rate of all engineering vertical transfer students from 2002-2019, n=4,102.

5.2.2 Trends in time to graduation. Extant literature lacks long-term data regarding the perseverance of transfer students in the field of engineering [24]. To address this knowledge gap, the following results seek to provide clarity on the typical duration it takes for vertical transfer students to complete their engineering bachelor's degrees.

Table 1. Average Number of Years Spent at UF Based on Degree Attainment. The Estimated Total Years to Bachelor's was calculated by adding two years the average number of years at UF.

Degree Attainment	Average Number of Years at UF ± Standard Deviation	Estimated Total Years to Bachelor's
No Degree	1.9 ± 1.5	N/A
Degree, not engineering	3.7 ± 1.8	5.7
Degree, engineering	3.4 ± 1.0	5.4

Table 1 shows the average number of years that vertical transfer students spent at SU based on their degree completion status. Notably, vertical transfer students who did not attain any degree during their tenure at SU had an average duration of 1.9 years at the institution. Previous literature has indicated that many institutional and individual factors play a role in why undergraduate students leave engineering programs [31]. These factors encompass a range of challenges, including negative perceptions and diminishing interest in engineering [86], difficulties with demanding prerequisite courses [87], insufficient academic advising, and restricted course availability [22]. Vertical transfer students who completed a degree outside of engineering averaged 3.7 years at SU, and students who earned engineering degrees averaged 3.4 years at SU. Given that we assume that it takes a student two years to complete their associate's degree at the starting community college, we find the average time for engineering degree attainment was approximately 5.4 years for engineering graduates and 5.7 years for students who switched from engineering before graduation (see Table 1).

We also examined the bachelor's degree attainment trends for each year after vertical transfer students first enrolled in SU. Figure 10 illustrates how bachelor's degree attainment changed based on the number of years each vertical transfer student spent at SU. The small number of vertical transfer students who spent seven or more years at SU were combined into one data point.

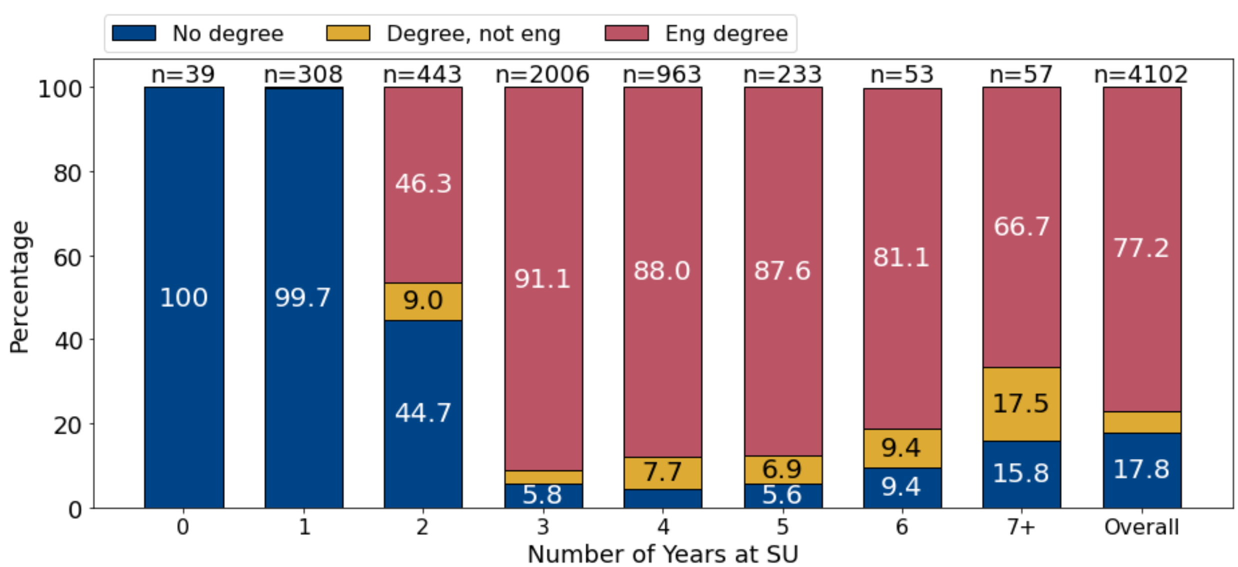

Figure 10. Percentage of Students by Degree Status Based on Number of Years at SU.

There was only one student across the dataset who earned an SU degree in one year, indicating that engineering vertical transfer students need at least two more years to earn a bachelor's degree. However, as shown in Figure 10, it is common for engineering vertical transfer students to take at least three additional years to earn a bachelor's degree. Vertical transfer students who chose to leave SU without a degree typically did so within their first two years. The percentage of students leaving without a degree decreases during the first three years and reaches its lowest point four years after the student enrolls. However, after the fourth year, the percentage of students leaving without a degree increases again. We also noted that after students spend three years at SU, they are more likely to leave with a non-engineering degree, indicating that many vertical transfer students take some engineering classes at SU and then decide to switch. Vertical transfer students who begin as engineering majors at SU before switching to a non-engineering major may take a higher number of courses and increase their time to degree.

5.2.3. Degree attainment trends by race/ethnicity. We also explored how bachelor's degree attainment differed based on racial/ethnic identity. Figure 11 shows the percentage of vertical transfer students across race/ethnicity subgroups who left without a degree, earned a non-engineering bachelor's degree, and earned an engineering bachelor's degree. While there are some minor differences in outcomes among vertical transfer students of different races, we did not notice any obvious trends.

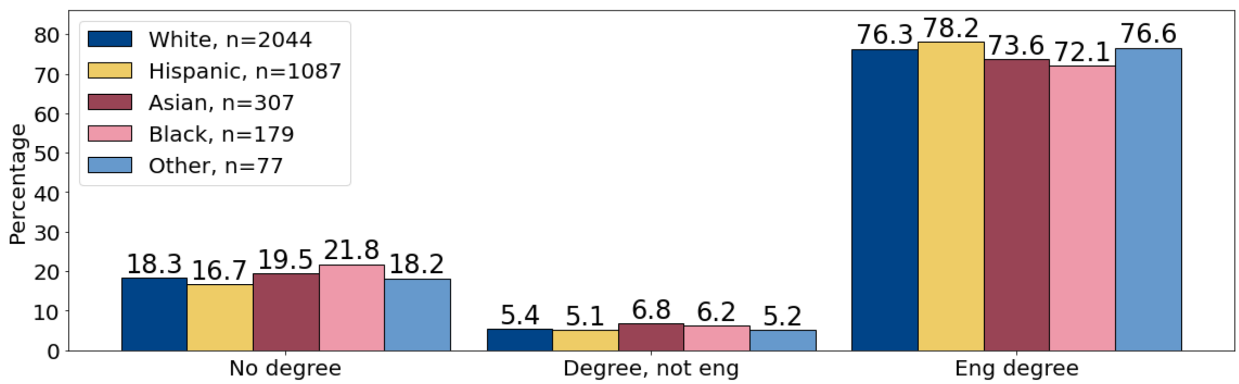

Figure 11. Degree Attainment Percentage of Engineering Vertical Transfer Students Based on Race/Ethnicity

5.2.4. Degree attainment trends by gender.

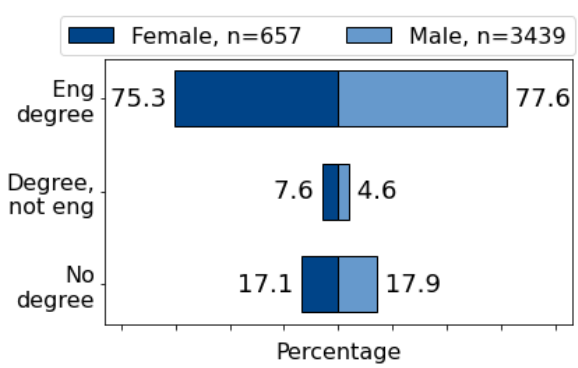

Figure 12. Degree attainment of engineering vertical transfer students by gender, n=4,096.

Figure 12 shows the degree attainment rates by gender for all vertical transfer students enrolling between 2002 and 2019. Men and women are similarly likely to leave without earning a bachelor's degree, with 17.9% of male transfer students leaving SU without a degree and 17.1% of female transfer students leaving SU without a degree.

For those completing a degree, there are distinct differences in the type of bachelor's degree earned. While male and female vertical transfer students completed a bachelor's degree at roughly the same rates, the proportion of men who earned an engineering bachelor's degree was slightly higher (2.3 percentage points). Similarly, the proportion of women who completed a non-engineering bachelor's degree was slightly higher (3.0 percentage points). This indicates that female vertical transfer students were about 1.7 times as likely to switch out of engineering than male vertical transfer students.

5.2.5. Degree attainment trends by international status.

We found that international and domestic students had some of the most glaring differences among the demographic groups included in this study. Figure 13 shows the degree attainment rates based on international status for all vertical transfer students enrolling between 2002 and 2019. Approximately 83.8% of international vertical transfer students earned an engineering bachelor's degree, but only 75.5% of domestic vertical transfer students achieved the same outcome.

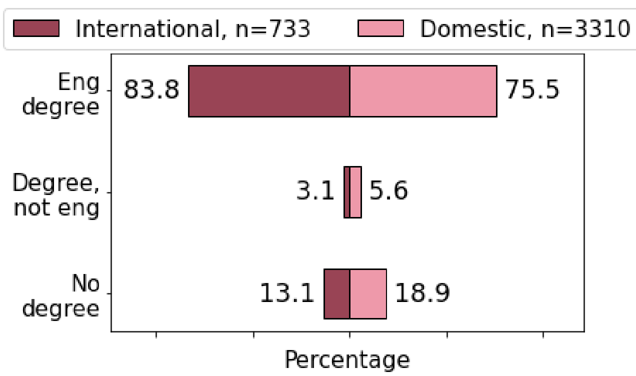

Figure 13. Degree attainment of engineering vertical transfer students by international status, n=4,043.

Consequently, a lower proportion of international vertical students earned a non-engineering bachelor's degree or left without a bachelor's degree. Nearly 19% of domestic vertical transfer students did not earn any bachelor's degree at SU, while only 13.1% of international vertical transfer students did not earn a bachelor's degree, indicating that domestic engineering vertical transfer students were 1.4 times as likely to leave SU without a degree than international engineering vertical transfer students. In addition, 5.6% of domestic vertical transfer students earned a non-engineering bachelor's degree from SU, while only 3.1% of international vertical transfer students earned a non-engineering bachelor's degree from SU. Domestic vertical transfer students were 1.8 times as likely to switch and earn a non-engineering bachelor's degree than international vertical transfer students.

5.2.6. Degree attainment trends by starting community college.

We also calculated the percentage of vertical transfer students from each starting community college who completed an engineering bachelor's degree, the percentage who completed a bachelor's degree outside of engineering, and the percentage who did not complete a degree. As in our enrollment analysis, we focused on State Colleges A, B, and C, the three largest feeder community colleges for the SU engineering degree programs.

Figure 14 shows the degree attainment rates for vertical transfer students from each college. Since State College A has a designated partnership with SU Engineering, we would expect State College A students to be more prepared for the vertical transfer and have higher engineering bachelor's degree attainment rates compared to other institutions without a designated partnership with SU. However, we found that State College A had the lowest engineering degree attainment rate and the highest non-degree attainment rate out of the three largest feeder community colleges. State College B (14.9%) and State College C (14.1%) have lower proportions of vertical transfer students who did not complete a degree than the overall engineering vertical transfer student population at SU. However, over 20% of State College A vertical transfer students left SU without completing their bachelor's degree.

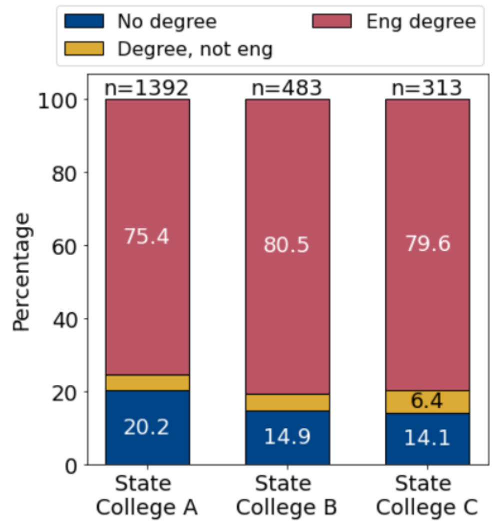

Figure 14. Degree attainment of students from the most common feeder colleges

5.2.7. Yearly degree attainment trends.

Our final analysis stage investigated the changes in degree attainment trends by calendar year. We were curious to see whether students were more successful as time passed. Figure 15 shows the degree attainment of students leaving SU in a given calendar year.

Overall, the yearly degree attainment rates remained relatively stable. However, a closer examination reveals that vertical transfer students experienced their lowest engineering degree attainment rates in 2018 and 2020. Furthermore, after initiating new partnership agreements with starting community colleges and modifying admission policies in 2012, SU observed an increase in overall graduation rates, along with a slight rise in the percentage of students earning engineering degrees until 2017. These findings underscore the impact of 4-year institutions in developing strategic transfer pathways through collaborations with community colleges. Nonetheless, it is noteworthy that despite these efforts, the number of degrees earned has plummeted back to levels seen 20 years ago. These results highlight the need for 4-year institutions to reassess the policies and strategies to support vertical transfer students during their post-transition transfer process.

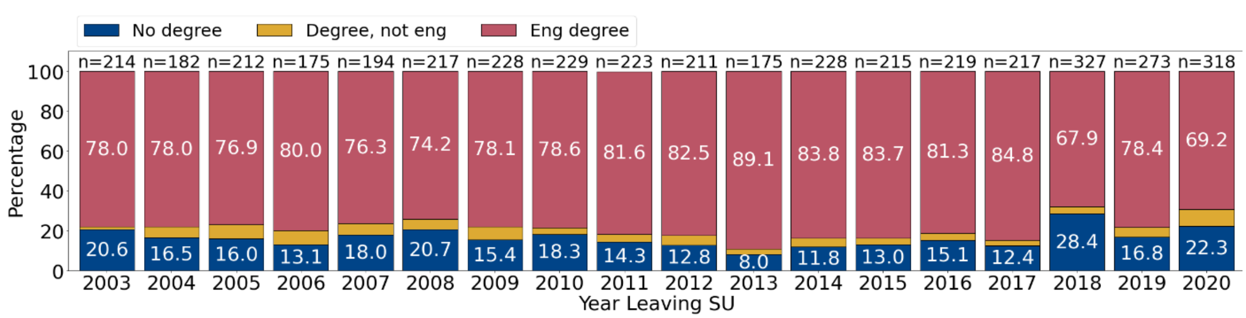

Figure 15. Degree Attainment for Students Leaving SU in a given calendar year.

6. CONCLUSIONS

This study offers several insights into the differences in engineering vertical transfer student outcomes. With each new insight pertaining to variations in vertical transfer students' enrollment and educational outcomes, we open another potential avenue of discovery and future inquiry.

Our findings regarding the six-year graduation rate of SU engineering vertical transfer students offer important insights. Within four years of SU enrollment (i.e., within six years of initial college enrollment), 74.5% of SU engineering vertical transfer students earned a bachelor's degree, which is substantially higher than the national average of 49.1% [29]. Our findings indicate that SU engineering vertical transfer students are about 1.5 times as likely to earn a bachelor's degree within six years as the general U.S. vertical transfer student population, but we caution the reader to interpret this statistic as a description of a trend that does not account for confounding background characteristics. When compared to the rest of the high-achieving student population at SU, SU engineering vertical transfer students have a lower six-year graduation rate. According to the SU website, the overall six-year graduation rate of SU students, regardless of major, is 91%. More work is needed to isolate the effects of the vertical transfer pathway to provide evidence-based recommendations in pursuit of equity in bachelor's degree completion rates in engineering degree programs among transfer and non-transfer students at SU.

Previous literature suggests that the average time to bachelor's degree completion in engineering can vary significantly among vertical transfer students, illustrating the importance of studies designed to help practitioners, policymakers, and researchers better understand the experiences and outcomes of engineering vertical transfer students. Our numbers are comparable to previous studies that reported the average time required for vertical transfer students to earn an engineering bachelor's degree to be 6.5 years, notably longer than the four-year timeframe for traditional bachelor's degree programs [88]. Another study presents data indicating that the average number of degree-enrolled years for graduation of the S-STEM vertical transfer cohort was 4.7 years compared to 4.9 years for transfer students who graduated with an engineering or computer science degree between Fall 2011 and Spring 2015 [89]. Moreover, the academic literature highlights various factors contributing to the extended duration of bachelor's degree completion for vertical transfer students. These factors include transfer shock [18], academic and social integration [10], ineffective advising, and limited course offerings [90]. Our findings align with prior work highlighting delays in obtaining a bachelor's degree among vertical transfer students, emphasizing the importance of addressing potential barriers to timely graduation to support engineering vertical transfer students and enhance their success in completing their bachelor's degrees and entering the labor market without extended delays. The multifaceted nature of the issue, as highlighted in the academic literature, underscores the need for targeted strategies and institutional support mechanisms to facilitate a smoother academic journey for vertical transfer students in engineering.

In analyzing bachelor's degree attainment among vertical transfer students based on the number of years enrolled at SU, we found that vertical transfer students who left without a degree typically did so within two years. This may be due to transfer shock, as previous research found that transfer shock continues throughout at least three semesters post-transfer [18]. Another important finding concerns the students leaving without a degree after more than four years. After spending four years or more at SU, vertical transfer students left without a degree at higher rates. This could be due to a variety of challenges and barriers, such as students' frustration at the extended time needed to obtain a bachelor's degree, but future research should examine why vertical transfer students disproportionately leave without a bachelor's degree toward the end of the pathway to completion.

Our findings did not reveal substantial differences in bachelor's degree attainment across race/ethnicity subgroups among vertical transfer students. Like earlier takeaways pertaining to the pooled analysis, additional data and further analyses are needed to better understand student experiences in the context of their racial and ethnic identity. Another insight from this study is the low representation of women in the engineering vertical transfer student population. One potential explanation is that approximately 16% of Florida community college engineering students are women, which would be consistent with the 16% women among SU engineering transfer students. Another possibility is that there is a higher percentage of women in community college engineering courses, but women are less likely to continue their engineering studies after transferring vertically to a four-year institution. Further inquiries related directly to gender discrepancies in engineering would represent an important contribution to academic literature.

Earlier work reported that female engineering vertical transfer students are more likely to switch to a non-engineering degree when compared to male transfer students. This differs from previous data, such as the 2017 ASEE Engineering by the Numbers report on engineering retention and time-to-graduation, which described average persistence and graduation rates for traditional engineering students [91]. According to this report, the persistence of women to the second year of engineering is about 1% higher than the overall national average [91]. Additionally, female students have a higher four-year and six-year engineering graduation rate when compared to the overall national average [91]. The bachelor's degree attainment trends for female engineering vertical transfer students at SU are different than the broader population of U.S. engineering vertical transfer students, and further research is needed to better understand these differences.

Another insight from this study is the difference in outcomes between international and domestic students. We found that international transfer students at SU complete an engineering bachelor's degree at higher rates and leave SU without a bachelor's degree at lower rates when compared to domestic vertical transfer students. Additionally, a lower proportion of international vertical transfer students switched to a non-engineering degree program when compared to domestic vertical transfer students. This discrepancy may be due to different attitudes and motivations between international and domestic students, but future qualitative work should seek to better understand these students' experiences and explore why their outcomes differ.

The high enrollment of vertical transfer students from State College A to SU may be attributed to several factors, including the geographical proximity to SU and the presence of a reverse transfer program for engineering students. Further research exploring the impact of partnership programs, such as the reverse transfer initiative, and conducting geographical accessibility studies would provide valuable insights into the dynamics influencing vertical transfer patterns and enrollment rates. The demographic composition of these community colleges suggests promising avenues for the recruitment of vertical transfer students from diverse backgrounds. As a reference, as reported by SU, 33% of the undergraduate engineering student population at SU are underrepresented minorities (URM). However, State College A has a student body that is 33% URM, with 22% Hispanic and 11% Black [85]. State College B has an enrollment of 86% URM, with 71% Hispanic and 15% Black [85]. State College C's enrollment is 68% URM, with 37% Hispanic and 31% Black [85].

7. SIGNIFICANCE AND FUTURE WORK

This study offers an overview of enrollment and attainment outcomes for engineering vertical transfer students at SU, laying the groundwork for future investigations into the underlying reasons for these trends and the causal impact of vertical transfer pathways on key outcomes. While our analysis provides insights using detailed longitudinal data, it serves as a starting point for deeper inquiry, acknowledging that statistics alone cannot fully explain the complex dynamics at play.

Moving forward, our focus will examine the post-transfer transition processes of engineering vertical transfer students across diverse demographic backgrounds, considering the contextual characteristics of large, highly selective research-intensive institutions. Additionally, we will also investigate the impact of institutional partnerships on success outcomes and develop strategies to support underrepresented minority students in engineering programs in their post-transfer transition processes.

8. AUTHORS' CONTRIBUTIONS

Conceptualization: Rivera-Jiménez and Ortagus conceived and designed the analysis, collected the data, and supervised the students who worked on the analysis for this paper. They also oversaw the project and funding acquisition. *Data Collection:* Rivera-Jiménez and Ortagus collected the data. *Data Cleaning and Descriptive Data Work:* Ortagus and Allchin cleaned the data, completed descriptive data work, and provided edits to the paper. *Data Analysis and Manuscript Writing:* Lubbe and Rivera-Jiménez performed the analysis, wrote the paper, and edited it. *Figures Contribution and Manuscript Editing:* Montiel contributed the figures and edited the paper.

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