Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025 ASEE
Paper ID #47570

Increasing Junior Level Standing at 4-year Aerospace, Mechanical and Civil Engineering Programs through Community College Transfer Credit Transparency

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Introduction

Politicians and higher education administrators have been trying to improve the experience for community college transfer students to 4-year public universities through reducing credit loss and increasing junior or third year standing when community college students pursue a 4-year degree. Some tried legislative routes to force 4-year institutions to accept associate degrees from community colleges as satisfying the first two years of a bachelor's degree. A recent book, *Power, Privilege, and Community College Transfer,* examined this attempt to shift power to the transfer student and how it influenced Texas institutions, advisors, and students. The authors explained that piece of legislation was largely symbolic and not enforceable. The legislation was not enforceable because within universities, programs still hold the authority to decide which credit counts toward their degree requirements [1]. This was especially true with programs that require complex pre-requisite structures within their degree requirements such as engineering. Without transfer credit transparency, the authors of the book demonstrated through student case studies that students were forced to triangulate the most reliable information from advisors and online resources.

The burden to navigate the path through community college and a 4-year institution to earn a bachelor's degree should not rest on the shoulders of the student to seek out the most reliable transfer credit information while studying at community college. Some of that work should be simplified by community colleges and 4-year institutions and their programs. As an alternative to using policy to increase junior level standing at the 4-year institution, Virginia, the state in this study, invested in curriculum alignment across colleges. This alignment allowed each 4-year institution the added efficiency of making one degree path per program for all the state's community colleges. They then did the harder work to help create maps of the curriculum across a student's associate and bachelor's degree requirements so students pursuing an associate degree could enroll in courses they knew would transfer toward a bachelor's degree, ultimately knowing which courses were remaining post-transfer across universities in a specific 4-year program. This effort aimed to increase transparency and empower students categorized as "resource curators," a term the book [1] used to describe students who sought out multiple forms of information to find the most reliable information to plan their course enrollment. This enabled 4-year degree programs to directly advise students while they pursued an associates degree at any Virginia Community College (VCC).

This state-wide effort was important because of the purpose society, industry and national leaders expect from higher education. It would be ethical and based more on a moral responsibility for our educational system and government to believe in and care about growing the intellectual capital of all its citizens [2]. However, research on this topic from the Community College Research Center and engineering education researchers located the source of interest for doing this important work as the need to meet the needs of industry. More specifically, states

need higher education to play a large role in workforce development to meet industry demand for engineers and computer scientists [3], [4]. This reliance on higher education to train the future workforce was named social efficiency [5]. Beyond social efficiency, Labaree explained social mobility was a common goal for higher education institutions; they are expected to prepare students to compete for social positions. This is particularly important when thinking about the transfer from community college to 4-year institution due to a higher percentage of limited income students. In short, there have been and will continue to be various, and at times, competing expectations for both 2-year and 4-year institutions. The combination of expectations of social efficiency and mobility work well withing engineering programs as long as engineering programs are equipped and expected to mobilize students independent of their income status coming into the university.

The National Student Clearinghouse Research Center (NSCR) reported that upward (we prefer the term vertical) transfer to highly selective institutions has been declining and continued to decline in Fall 2022 [6]. Researchers defined upward or vertical transfer as a student transferring from a 2-year to a 4-year institution to pursue a bachelor's degree. The decline was greater for those earning an associate degree prior to transfer. Associate degree earners who transferred were down more than 12% as compared to 5% without an associate degree. Based on recent research on transfer academic success post-transfer, this is most concerning as vertical transfers earning an associates prior to transfer were more likely to graduate with their bachelors in engineering [7]. Since this study took place in Virginia, it is helpful to know Virginia had a decline state-wide in transfers from 2018 to 2022, going from around 34,000 to 29,000 transfers and an increasing percentage of those transfers coming from out of state. In 2018 and 2022, students transferring from outside of Virginia made up 33% and 38% respectively of those who transferred, increasing by 5%.

Considering this decline in both enrollment and associate degree completers, we hope the percentage of in-state transfer with associate completers increases by the next NSCR report due to, in part, the work Virginia and its institutions conducted to improve the clarity of path from 2-year to 4-year degree completion. In the meantime, we wanted to examine any change in percentage of students matriculating at the University of Virginia's School of Engineering and Applied Science (UVA Engineering) at junior level in a shorter horizon based on the publication of the transfer guides in 2022. We examined the academic year standing of the transfers at UVA Engineering instead of associates earned as their evaluation of academic year upon matriculation at a 4-year institution determined tuition charges. This initiative was an important step to improve the transfer experience as it spans the pre- and post- transfer phases explained in the following section.

Literature Review

It is important to know where increasing junior standing is situated in what literature defined as a transfer-receptive culture. Herra and Jain outlined stages, pre- and post-transfer, and efforts which contribute toward a transfer-receptive culture [8]. First, the pre-transfer effort

focuses on the variety of needs among transfer students – nontraditional, first-generation, limited-income, and minoritized students. Institutions meet this standard through measuring not only their accessibility of application and matriculation but also through retention and graduation rates to ensure the outcome of educational pursuits matches the overall student body. Second, pre-transfer effort should provide outreach and resources, knowing the needs of the students coming from community colleges and with the knowledge of their mission to transfer. Literature and government reports pointed to a need for four year institutions to understand the information students need around transfer of credits [1], [9]. Following pre-transfer effort is post-transfer reception.

In post-transfer effort, the institution or school should first be supportive and carve out opportunities for nontraditional reentry at high levels of academic achievement. Support should include financial and academic support. Second in post-transfer effort should be acknowledging how academics intersects with a student's community and family. And lastly, institutions and schools should assess, evaluate and improve transfer-receptive programs and initiatives that can further inform the improvement of the student experience for students who transfer. It is important to note that "community college transfer students who enroll in very selective four-year institutions are more likely to be low-income, Black and Hispanic in comparison to their non-transfer peers" [3, p.1] and can broaden the impact these institutions can have on the purpose already mentioned that public institutions have been expected to serve society through social efficiency and mobility. Institutions can only help increase mobility if they are able to serve more limited income students and those not initially enrolling in 4-year institutions.

Within engineering education literature, a systematic literature review of factors positively contributing to engineering transfer persistence was conducted [10]. The three factors were the amount and type of courses completed at the CC, increasing student integration at the 4-year institution, and establishing an institutional culture inclusive of transfers.

Context

UVA Engineering is a mid-Atlantic, 4-year public, Research I institution, enrolling 17,000 undergraduates with about 3,000 enrolled in engineering. The engineering school has traditionally admitted around 60-70 external transfers each fall into its engineering programs, aiming to increase this number through efforts described in the literature above. UVA Engineering is situated in a university who has publicized findings of its social efficiency and mobility well [11], [12]. Because of this publicity, UVA claims to empower limited-income students to be able to be successful and graduate with their 4-year degree and realize a substantial return on their investment.

To participate in the state-wide effort to make transfer and earning a 4-year degree in engineering more transparent, the engineering school dedicated faculty service time across its undergraduate programs to align VCC common 2-year curriculum with the 4-year institutions' curriculums. This state-wide effort aimed to align at least 80% of the state's VCC with the many 4-year curriculums. In Appendix A, we explained the process the Mechanical and Engineering

faculty member was involved in, so other states and engineering schools have a sense of the scope of this work.

To situate the transfer guide work in the context of other pre- and post- transfer efforts and the factors in the systematic literature review, we captured several examples to clarify that transfer guides alone were not sufficient to create a transfer-receptive culture, and that UVA continues to do work to improve transfer student persistence and success. In 2021, the institution partnered with the local CC (Piedmont Virginia Community College, PVCC), hired a dedicated staff member to be a liaison to PVCC students, and offered an application to receive a robust scholarship especially for limited income, first generation, and minoritized PVCC students. School administrators provided virtual transfer sessions as well as in person visits to classes and engineering clubs. Grant-based programs were offered by engineering departments and include pre- and post- transfer contact with faculty, research and industry.

UVA Engineering's Undergraduate Programs Office provided transfer specific summer orientation, assigned a transfer specific advisor and welcoming events in engineering, including career, student organization fair, and interacting with the engineering student council leader specific to transfer initiatives. This up front, transfer specific programming also allowed transfers to network with other engineering transfers. In 2022, the university started celebrating the National Transfer Student Week through Student and Academic Affairs programming. Through an annual VCC and UVA Engineering Transfer Conference starting in 2023, the engineering school brought together 4-year and 2-year engineering program heads and shared admission, matriculation, academic performance metrics, and graduation outcomes. Departmental efforts to create a transfer-receptive culture are captured in Appendix A. These details were provided as VCC student started in programs and the work that departments do was impactful for student success. These efforts included capturing students' negative and positive undergraduate experiences. The department learned their transfer student experience was lagging in involvement in extracurricular activities; whereas, they reported a positive advising experience. The department also examined academic performance and found transfer students earned slightly lower grades.

Research Question

Since higher education literature on transfer student experience called for 4-year institutions to assess and disseminate what we found to the engineering education community, we examined and reported on the following questions around specific pre- and post-transfer efforts.

1. Comparing percentages of incoming engineering undergraduates, pre- and post-state intervention to increase community college transfer credit transparency toward engineering bachelor's degree requirements, was there an increase in percentage of VCC transfers at junior level or third year standing at UVA Engineering?
2. What percentage of VCC transfers graduated within 6 semesters at UVA Engineering?

Methods

We analyzed student record data from external transfers admitted to Aerospace Engineering (AE), Civil Engineering (Civil) and Mechanical Engineering (ME) from Fall 2014 to Fall 2024 at UVA Engineering. The dataset included student admission information, transfer credits and institution, enrollment and graduation data. We included all transfers who were admitted as engineering undergraduates with some transfer credit from an in-state community college to locate the vertical, in-state transfers. Students who were admitted to another college or school within UVA with subsequent transfer internal to the university were not included. We also did not include transfer students who did not transfer in credits from an in-state community college (i.e. not included transfers with credit only from a 4-year institution, "lateral transfers"). Our dataset contained 236 students across the three majors, of which 159 (67%) transferred credit from a single or multiple Virginia Community Colleges (VCCs). Based on transfer credit data, we created a flag variable to identify transfer students who brought in credit from an in-state community college rather than relying on their previous or sending institution. This method of including vertical transfer by credits and not their last or sending institution was suggested by other researchers [7], [13]. We did not collect data on which external transfers utilized the transfer guides.

For graduation rate analysis, we used the standard higher education timeline to degree, which is time-and-a-half or 3-year or 6 semester period. This is slightly different from previous engineering education literature which considered graduation rates with a 4 year or 8 semester period [7]. Using the 3-year period, we narrowed the dataset to cohorts admitted Fall 2014 to Fall 2021. The data we used to analyze graduation rates included a total of 103 students. The external transfer size overall was small and became smaller as we narrowed down to just three majors. So we reported in aggregate to follow Institutional Review Board standards to protect the anonymity of individual students. We only reported sample sizes of 8 or more students (IRB #7056). This also limited our ability to disaggregate by student demographics important to understanding educational outcomes by a group students identify with (limited income, first generation, etc).

Results

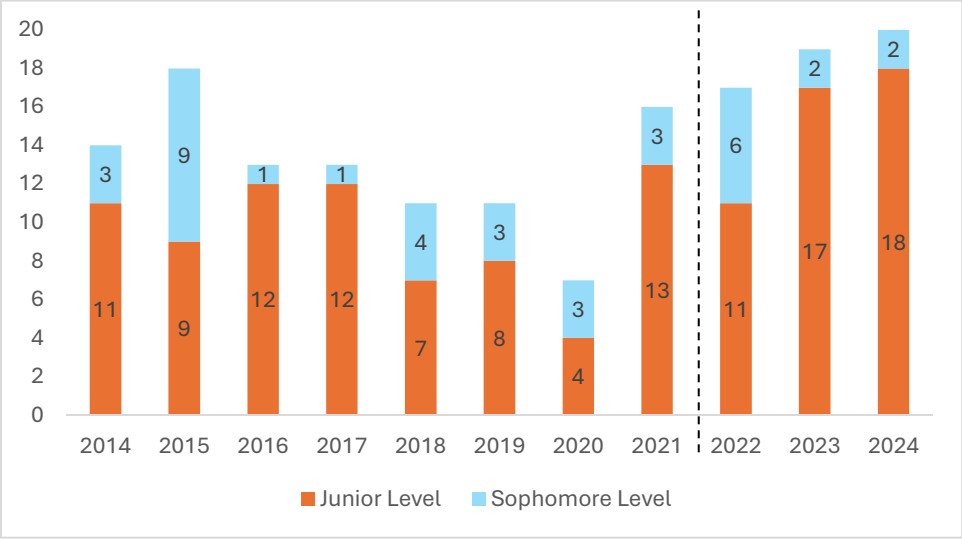
For the first research question, there was an increase in percentage of junior level or third year students admitted to Aerospace, Civil and Mechanical Engineering programs. See Table 1 for counts and percentages before and after the university worked with the state to publish the transfer guides. We found that prior to the transfer guides being published that 74% of the incoming class who had transferred into the three majors were evaluated to be at junior standing. After the transfer guides were published, 82% were evaluated at junior level, for an increase of 8%.

We visualized the transfer trends of these three programs in Graph 1. Similar to trends across the nation where CC transfer to 4-year was declining, these three programs saw the lowest

Table 1. Percentage of Student Academic Year Standing Comparing Pre- (Fall 2014 - 2021) and Post-Transfer Guide (Fall 2022 - 2024) among Aerospace, Civil, & Mechanical Engineering majors who Transferred from In-State Community Colleges

Admit Year	Second-Year Transfer	Third-Year Transfer
2014-2021	26%	**74%**
2022-2024	18%	**82%**

Graph 1. Count of Undergraduates who Transferred from Community College into 4-year Aerospace, Civil or Mechanical Engineering major from 2014 to 2024 by level



Note: The Global Pandemic initially impacted students and institutions in spring 2020. The vertical line represents the point in time where transfer guides were established for these majors.

Table 2. Counts of Engineering Undergraduates by Timeline to Graduate among Aerospace, Civil, and Mechanical Engineering majors who Transferred from In-State Community Colleges between 2014 and 2021.

Time to Degree Completion	Freq.	Percent	Cum.
4 semesters	44	42.7%	42.7%
5 semesters	14	13.6%	56.3%
6 semesters	37	35.9%	92.2%
Not graduating in 6 semesters	8	7.8%	100.0%
Total	103	100%	100%

transfer enrollment in 2020. Even as the percentage of vertical transfers and especially associate degree earners were declining in this state from 2018 to 2022, there was growth in transfer enrollment in these programs from 11 to 16. The fact that UVA Engineering transfer enrollment increased from students coming from VCCs may suggest the partnership and work that went into developing the curricular alignment and publication of the transfer guides played a role in improving engineering transfer enrollment and access. In addition to access, there were also financial aid implications for students based on second- or third-year status upon enrollment. The difference in tuition for UVA Engineering between sophomore and junior level in 2021 was $2000 [14]. More significantly, the difference between paying for another year at the 4-year institution as compared to a VCC was $31,548 [15]. Virginia's effort would have saved each student $33,548 by supporting the student to maximize the credits transferred from earning an associates.

For our second research question, we found a 92.2% six semester graduation rate (equivalent to a 5-year graduation rate, assuming two years at CC) for students in our dataset and reported counts and percentages by time to degree in Table 2. Unlike existing research which used a 6-year horizon and found CC transfers graduated at a higher rate [7], we found CC transfer students graduated at slightly lower rates than first-time, first year engineering students with a 5-year graduation rate of 94.2%, a difference of 2%. For national context, engineering program 6-year graduation rates were around 50% for engineering undergraduate [16].

Conclusion

The Community College Research Center explained that community colleges partnering with 4-year institutions play a critical role in meeting industry demand for engineering talent [3], [4]. To meet that goal, they also called for more transfers to enroll at highly selective institutions. More studies on 4-year degree granting departments need to examine the ways this partnership can flourish to benefit transfer students. Considering a state-wide decline in community college transfers and associate degree earners in Virginia, we reported an increase of VCC student transfers enrolling at UVA Engineering, a highly selective institution. We found amid this increase in enrollment that a greater percentage of community college students entered three engineering majors at junior level standing, saving students and the institution money and time to complete an engineering degree. We recommend other states or institutions take these steps after examining financial efficiency gained and reviewing the mission of the 4-year institution and its role in state efforts to serve and develop engineering talent. Great effort went into aligning VCC curriculum as well as 4-year faculty time to develop greater transparency for students through transfer guides. With 8% gain in junior level standing among vertical in-state transfer at one 4-year public engineering program, there were numerous other 4-year institutions in Virginia whose students and institutions realized their own gains. So state-wide effort extends the benefits more widely than this one study captured. For Virginia, initially reporting this gain signaled the faculty, administrators and state's time was worth the effort.

To further validate efforts to make transfer credits transparent by major, institutions should evaluate changes in junior level standing to continue to examine the effort going into the maintenance of transfer guides. This effort should be in addition to other transfer-receptive

efforts such as increasing the amount and type of courses students complete at the CC which best prepare students to succeed, increasing student integration at the 4-year institution, and establishing an institutional culture inclusive of transfers. This effort can be achieved through communication between 4-year and 2-year institutions on a regular cycle about the content of course material helpful for transfers to learn, creating transfer guides to align associate degree requirements with multiple institution's bachelor's degree requirements, access to faculty and peer mentorship across degrees, and supports addressing the needs of transfers.

Based on the findings that the percentage of vertical engineering transfer students started at the junior level, we recommend other states governments invest in personal and a process to make and sustain transfer credit transparency. Saving students upwards of $30,000 makes a substantial difference as the percentage of limited income students is higher among vertical transfers. The process and personnel should support 2-year and 4-year institutions to work toward greater alignment of curriculum as well as publish documents at the state level which can empower community college students. This is to help those community college students who are resource curators, looking for the most reliable information.

Without state staffing and website technical support, individual engineering programs could write faculty support for this effort into their broader impact plans for national grants to widen the participation in engineering, including annual gatherings that bring together registrars, engineering program directors and engineering community college faculty. Presidents and Deans at selective 4-year institutions can invest time to visit community colleges and learn what barriers exist in the transfer experience.

National conferences can help to establish and maintain relationships between community college engineering program leads and 4-year institutions. Community college faculty can receive a discount to attend the conference and part of the broader impact funding can go toward supplementing conference cost for those community college faculty and students who might have limited funding to attend. Student panels could be organized to enable a deeper understanding within states of the kinds of barriers transfer students face.

Engineering school leadership at 4-year institutions can use the framework for a transfer-receptive culture in their strategic plans school wide and by department [8]. There is a call to increase the percentage of transfer students into highly selective public institutions. In conjunction to broaden that access, engineering programs should ensure they are implementing both the pre- and post-transfer efforts [8]:

1. Pre-transfer: identify the strengths, needs and differences in experience among transfer students – nontraditional, first-generation, limited-income, and minoritized students
2. Pre-transfer: proactively reach out and develop relationships with community college students and their engineering faculty needs and understand the community college mission to transfer
3. Post-transfer: supporting and carving out opportunities for nontraditional reentry at high levels of academic achievement, including departmental scholarships, research and student organization involvement and leadership opportunities.

4. Post-transfer: acknowledging how academics intersect with a student's community and family. This can be a source of pride and motivation for pursuing the transfer path. It is helpful to see this as a strength of the student.
5. Post-transfer: sustain a framework or effort to assess, evaluate and improve transfer-receptive programs and initiatives that can further inform the improvement of the student experience

Future Research

We recommend researchers find a way to capture which students utilized the transfer guides to more clearly demonstrate the impact they had on improving the transfer process. This could be in the form of an intake student reported survey or a system built into accessing the transfer guides. While we do not claim the transfer guides caused the increase in junior or third year standing, we expect that the guides along with the collaboration played a role in the increase. For graduation rates, we expect to continue to monitor the graduation rates of the students who had access to the published transfer guides. While there is little room for improvement beyond a 92.2% graduation rate within 6 semesters, we expect a higher rate of 4 and 5 semester graduates within these programs.

This study could be expanded across the state to realize any growth in its state investment in human capitol. A state-wide study could also capture the increase in meeting the state-wide demand for engineering talent.

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Appendix A

Engineering through Transfer Work Day

In November 2019, "Engineering through Transfer Work Day" event brought together registrars, faculty, advisors, and other curriculum experts from 2-year and 4-year state institutions. The event established representative stakeholders, evaluated alignment opportunities for the first two years of each engineering program, identified alignment challenges, and brainstormed solutions. By this time, the community colleges (CC) had already initiated adopting common course names and numbers. Though there were some differences in the curricula between the 4-year institutions, we found that the Mechanical and Aerospace Engineering (MAE) programs had much in common and that the CC pre-engineering course offerings were sufficient to prepare AS graduates to enter these programs in the 3rd year. At our institution, the prerequisite courses for both the Mechanical and Aerospace curricula are Statics, Dynamics, Strengths of Materials, and Thermodynamics. All the CC transfer students were getting Statics and typically 2 of the other 3, with Thermodynamics being the only course that was not then available at all CC campuses. At this point, the working groups began a 2-year process of reviewing (and revising as needed) course syllabi so that student outcomes and preparation empowered successful transfer into the 4-year programs. The goal was to focus on ensuring students would be prepared for follow-on courses and not to be overly prescriptive.

Development of 2-4 Year Transfer Guide

The MAE faculty felt it was important to maintain differentiating hallmarks of our programs without unnecessary roadblocks for transfer students. Thus, in developing the 2-4-year transfer guides, we focused on core prerequisites needed to prepare for the 3rd year curriculum. Other courses could be shifted; transfer students tend to come in 'ahead of schedule' in terms of both technical and non-technical electives giving them room to pick up required courses (that are not prerequisites) in later semesters.

The prerequisite courses for the ME 3rd year curriculum were Dynamics (prerequisite for Mechanical Systems), Strengths of Materials (prerequisite for Structures), and Thermodynamics (recommended for Fluid Mechanics.) The Aero program had similar requirements needing Dynamics for Flight Vehicle Dynamics and Astronautics in the 3rd year. After a MAE faculty discussion, we decided to drop Thermo as a prerequisite for Fluid Mechanics. This was significant for two reasons: (1) it was more likely for a transfer to not bring in credit for Thermo and (2) Aerospace engineering majors need to take Fluid Mechanics in the fall of their 3rd year to graduate in 4 semesters. The faculty also decided to count an extra Intro to Engineering course credit toward one credit of their Computer Aided Design (CAD) course. They did this because a common complaint from transfer students was that this aspect of the course was redundant for them. To solve this issue, the Intro to Mech and Aero courses were split from 3 credits to a 2-credit Intro to major course and a 1-credit CAD lab course. Therefore, CC transfer students who fulfilled the pre-engineering curriculum also satisfied the CAD class.

Beyond curriculum – integrating transfer students into the MAE community

To address the post-transfer effort to create a transfer-receptive culture, the MAE department engaged in a university-wide initiative to improve undergraduate experiences in STEM which includes taking stock of current performance metrics (grades, matriculation rates) and student perceptions such as belonging and self-efficacy, and then engaging in projects to improve outcomes across all populations. For transfer students, we identified a concern over the grade differential between transfer students and first-time, first year students. In addition, from student survey data, we found that transfer students spend less time with extracurricular activities but have a more positive experience from academic advising. In MAE, all faculty serve as academic advisors for undergraduates, but the most seasoned advisors are paired with transfer students, which likely accounted for the positive outcome.