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Credit Loss for Engineering Transfer Students: Visualizations Across Students and Structures

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Credit Loss for Engineering Transfer Students:

Visualizations Across Students & Structures

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VIRGINIA TECH

NSF

NATIONAL PRIORITY

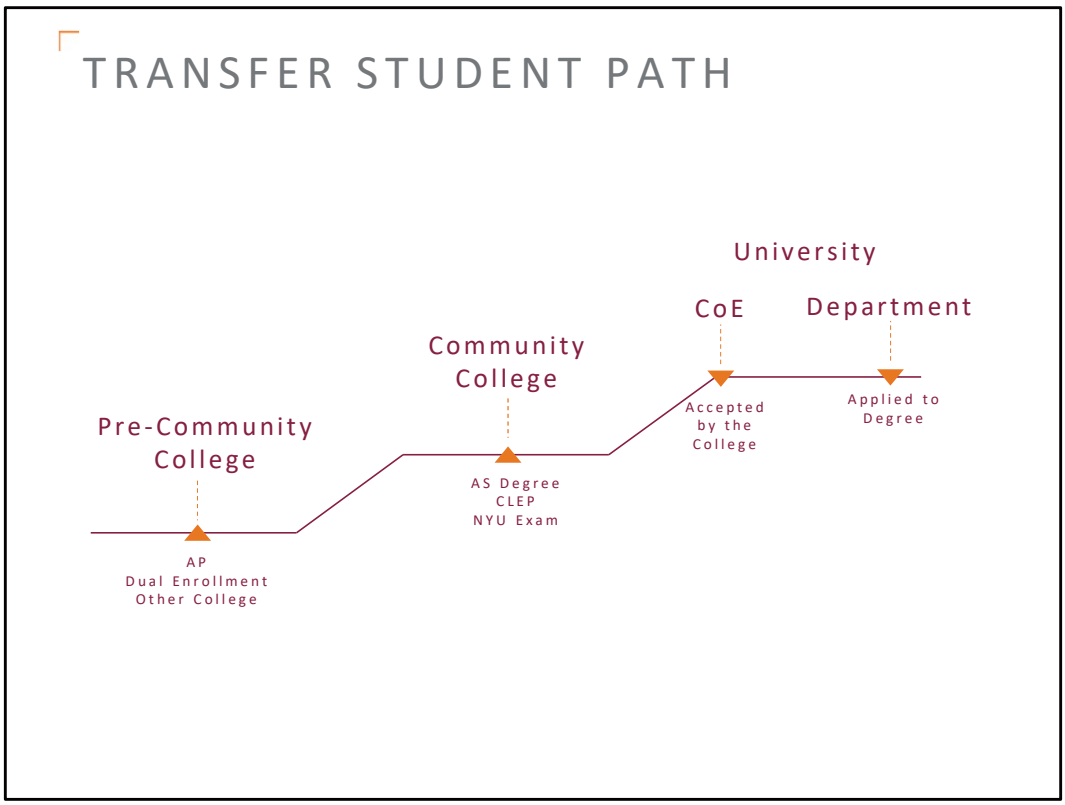
INCREASE GRADUATES

President's Council of Advisors on Science and Technology estimated that the United States will need ***1 million additional STEM professionals***.

BROADEN PARTICIPATION

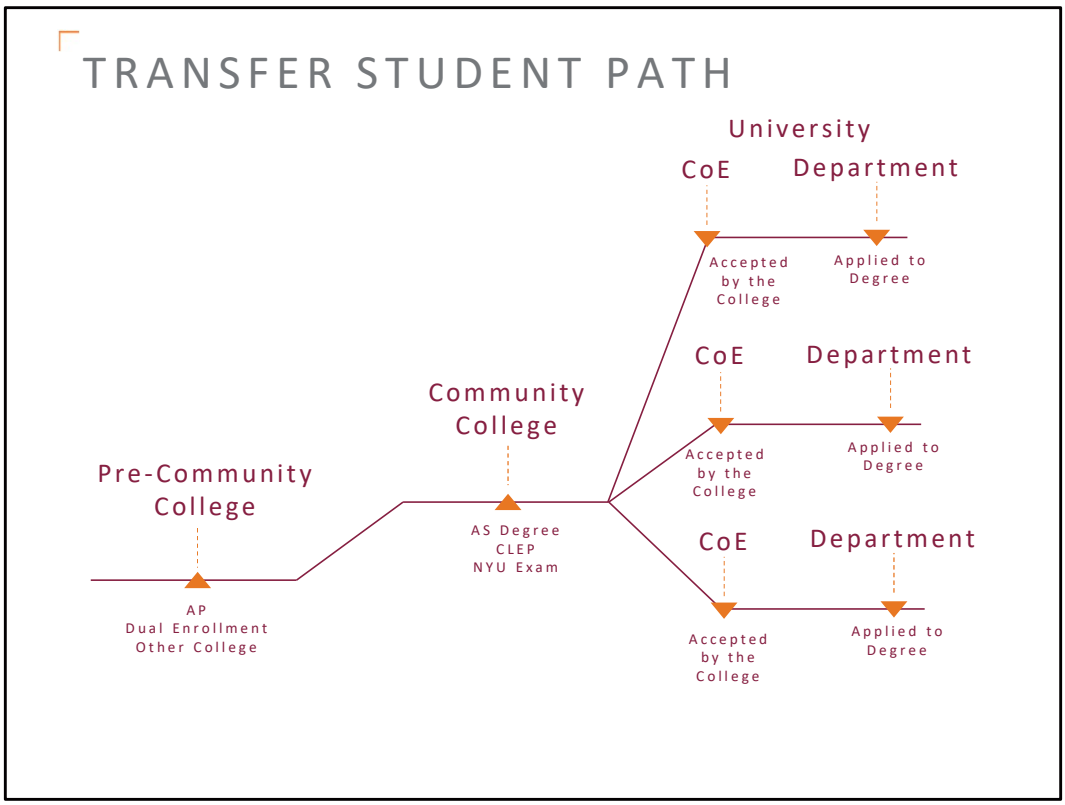
Underrepresented groups in engineering are also the fastest growing segment of the general population, and so it is also important that the field similarly reflect the population it serves.

Among the national priorities are increasing graduates in STEM and broadening participation in engineering. One recommendation from National Academy of Engineering (2013) emphasizes building transfer pathways from community colleges to universities to accomplish both goals.

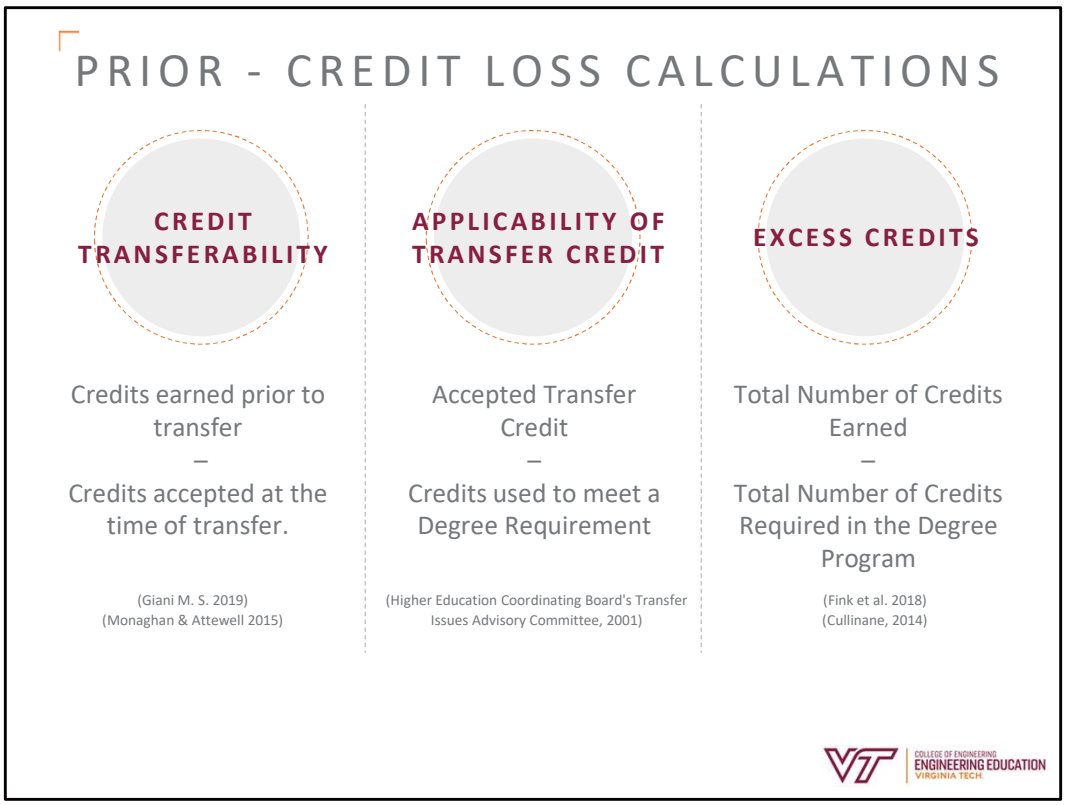


An idealized path for a transfer student depicted here. Accumulating credit at many points along the way. Students can earn credit prior to community college enrollment by taking AP, IB, and dual enrollment in high school. Additionally, students can come to community college with military credits, or transferred from another post-secondary institution. While at community college student can take CLEP or NYU exams and, of course, take classes at the community college. A student is then accepted at a University, so the prior credits are evaluated and accepted or denied. Then those accepted credits are either applied to their degree or marked as Unused.

This linear interpretation is idealized, but this does not represent the often circuitous pathways that transfer students actually take.



This type of path is still overly simplified but shows some broader considerations. While students are at community college, they are considering many receiving institutions. This makes choosing classes that transfer complicated which leads to potential credit loss.



There are very few studies that quantify Credit Loss. These calculations are highly dependent on the type of data collected. Here are three examples of credit loss calculations in prior work:

Credit Transferability

Credit transferability compares the number of credits a student earns prior to transfer to the number of credits accepted at the receiving institution. Research indicates widespread credit loss among transfer students, impacting their graduation prospects (Monaghan & Attewell, 2015). Credit transferability varies across states and demographic factors, emphasizing the contextual nature of the issue (Giani, 2019). No indication of how the credits were applied to the degree

Applicability of Transfer Credit

Credit Applicability refers to the number of transfer credits used to meet a degree requirement. This metric is challenging to assess due to data constraints, however, it is crucial in understanding the effectiveness of the transfer pathway. Researchers found that 83 percent of pre-transfer credits were accepted to the university, whereas only 70 percent of pre-transfer credits were actually applied to the degree (Texas Higher Education Coordinating Board., 2001). Does not account for pre-transfer courses that the institution did not accept

Excess Credit

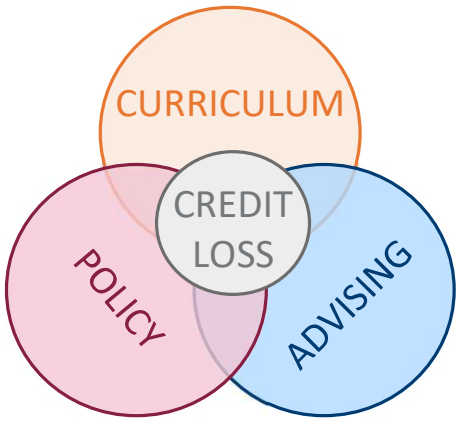
Excess credits among completers is calculated by subtracting the total number of credits required for a degree from the total number of credits earned. Such studies reveal that transfer students often take longer to graduate and accumulate more credits compared to their non-transfer counterparts (Fink et al., 2018; Xu et al., 2016). No indication if extra classes were a result of transfer.

The common result is that Credit Loss among transfer students is widespread and negatively affects degree attainment. However, there is no indication of the sources of this loss. Our study builds upon this research on credit loss by investigating how credit flows

from community college through transfer.

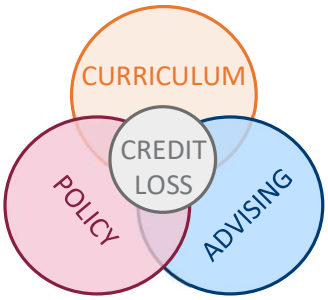
LITERATURE REVIEW

FACTORS THAT AFFECT CREDIT LOSS



Although there is limited research quantifying credit loss, there is research on factors that affect credit loss focused on three areas: Curriculum, Policy, Advising.

LITERATURE REVIEW



CURRICULUM

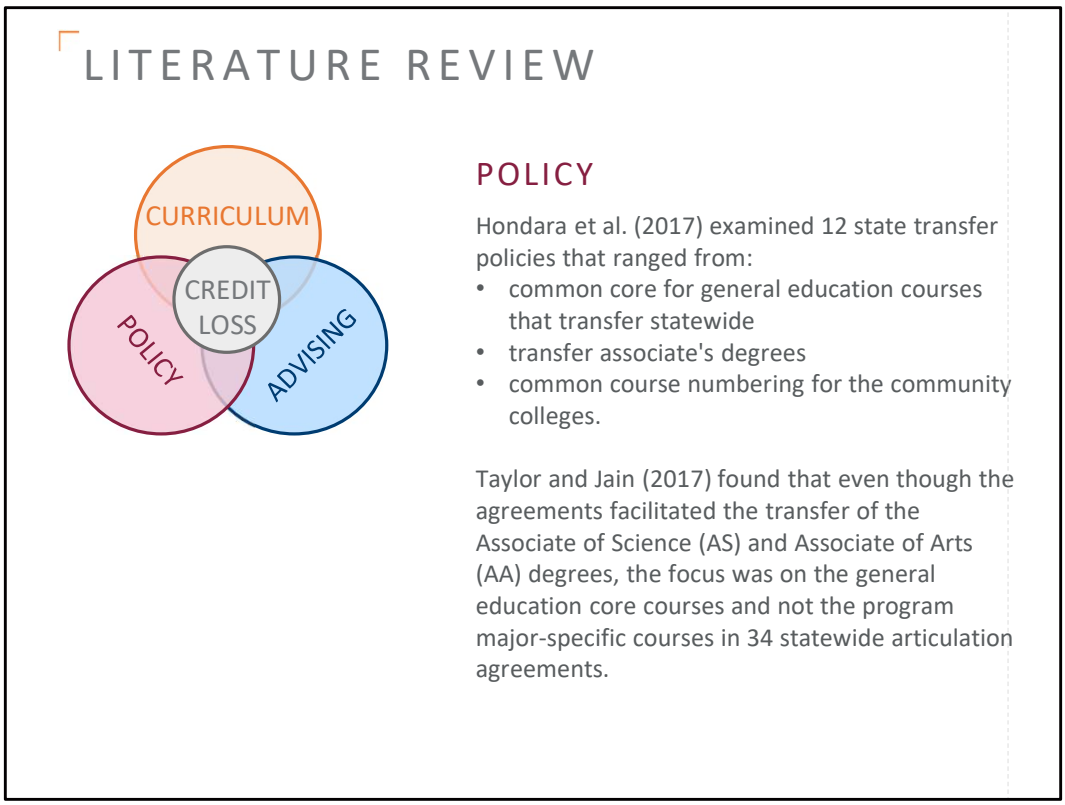
Heilman et al. (2019) compared the curricular complexity of electrical engineering programs at 63 different US universities and found statistically significant variation across these programs.

Grote et al. (2020) compared curricular complexity scores for multiple engineering disciplines at Virginia Tech and found significant variation across these disciplines.

Curricular complexity quantifies the course sequencing using pre-and co-requisites. Engineering bachelor's degrees tend to be the most complex curricula at a university when comparing curricular metrics across different degree programs (Heileman et al., 2019). For example, Heileman et al. (2019) compared the curricular complexity of electrical engineering programs at 63 different U.S. universities and found statistically significant variation across these programs.

Building on this work, Grote et al. (2020a) compared curricular complexities of engineering programs for community colleges and universities across engineering disciplines. They calculated curricular complexity scores for multiple engineering disciplines at Virginia Tech and found significant variation across these disciplines. The authors completed the same curricular complexity calculation for transfer students who started at a community college and then transferred to a university for the same engineering disciplines. They found the community college-to-university pathway was less complex than the pathway entirely housed at the university. However, even though the transfer pathway was less complex, the time to degree completion was longer. This longer time to degree indicates that other factors can increase the time to completion for transfer students, including credit loss, specifically with respect to credits not being applied to a degree requirement.

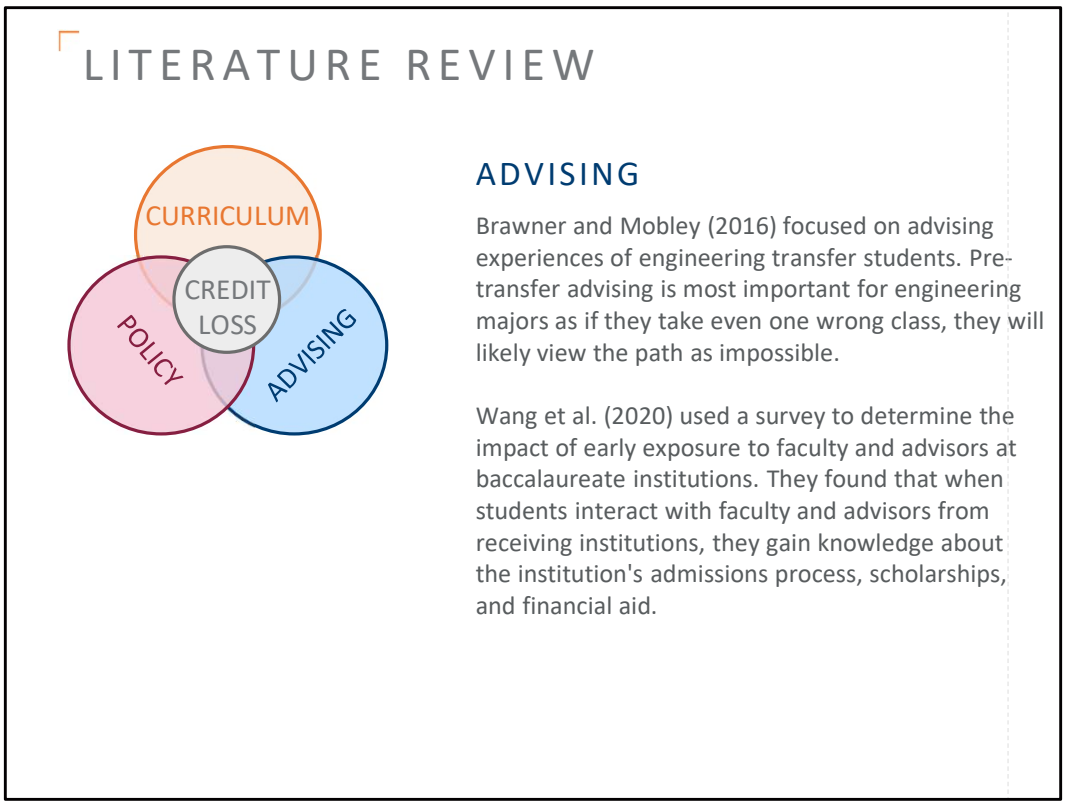
For engineering transfer students, this variation makes choosing transferrable courses confusing and complicated, particularly if a student is uncertain in selecting a discipline and transfer institution.



To aid credit mobility and ease confusion around curricula, states and higher education institutions put transfer policies and articulation agreements into place. Although agreements between community colleges and universities vary in components addressed, a commonality typically aims to preserve credits for transfer students (Roksa & Keith, 2008).

Hodara et al. (2017) examined 12 state transfer policies that ranged from the common core for general education courses that transfer statewide, transfer associate's degrees, and common course numbering for the community colleges. They found that the ultimate objective of these policies is not being realized because degree requirements vary drastically from university to university for STEM programs. The authors noted that for the policies to work as intended, community college students must choose a major and transfer institution early in their college careers to mitigate the potential for credit loss.

In their analysis of 34 statewide articulation agreements, Taylor and Jain (2017) found that even though the agreements facilitate the transfer of credits from the associate of science (AS) and associate of arts (AA) degrees to be able to be used for a bachelor's degree, the focus tends to be on general education core courses and not the program major-specific courses. In engineering programs, the major-specific courses are highly sequential, so missing a course or taking a class that does not meet transfer criteria could set transfer students back in their progress to a degree because of the curricular complexity of the engineering discipline.



Academic advising at the community college disseminates information about curricula, both at the community college and the university, and policies to guide students to a successful transfer.

Brawner and Mobley (2016) focused on advising experiences of engineering transfer students by analyzing transfer student interviews across five institutions. Although this study reinforces prior assertions that pre-transfer advising is crucial for successful transfer, it also highlights how essential accurate advising can be for engineering majors. The authors state that if an engineering student takes the wrong class because of poor advising, they will likely view the transfer path as impossible. This misadvising can lead to a change of major or dropping out of college altogether. In addition, Brawner and Mobley (2016) found that transfer students often self-advise using online resources but find the sites hard to navigate.

Wang et al. (2020) used a longitudinal survey of just over 1000 community college students to determine the impact of early exposure to faculty members and advisors at baccalaureate institutions. They found that when students interact with faculty members and advisors from receiving institutions, they gain knowledge about the institution's admissions process, scholarships, and financial aid. These pre-transfer interactions help facilitate a faster time to a degree since students did not accumulate credits that do not transfer.

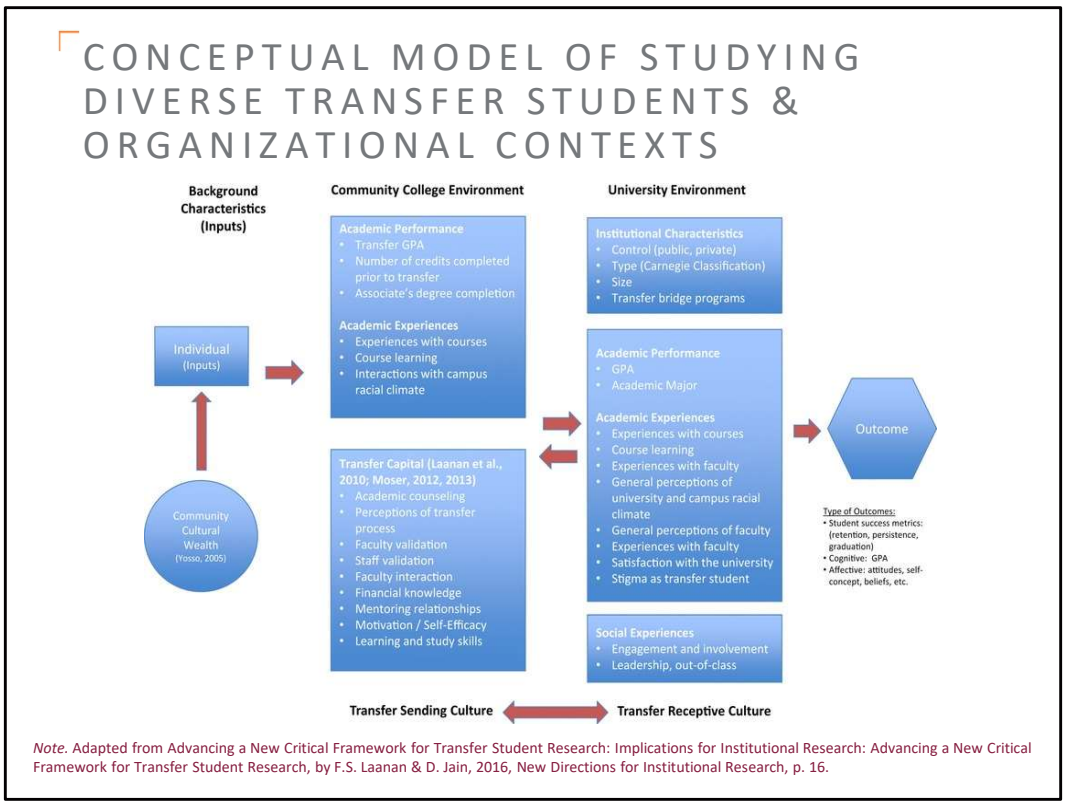
RESEARCH QUESTION

CREDIT LOSS AT TRANSFER

What are the sources of credit loss (e.g., pre-community college, AS degree credit, transfer loss, and applied to degree loss) at transfer for engineering transfer students?

Our study builds upon all this prior research on credit loss by investigating how credit flows from community college through transfer to a bachelor's degree in a comprehensive manner. Credits can be lost at the community college, during transfer, and at the receiving institution (Logue et al., 2022)— our work considers all of the different ways to measure credit loss reviewed in the prior sections but also consider new approaches to capture the full system. Credit loss can significantly impact transfer students enrolled in highly sequential degrees, such as engineering. Gaining a better understanding of how credits move through the transfer system for vertical transfer students in engineering can better inform conversations around policy, advising, and curriculum.

Our research question is: What are the sources of credit loss (e.g., pre-community college, AS degree credit, transfer loss, and applied to degree loss) at transfer for engineering transfer students?



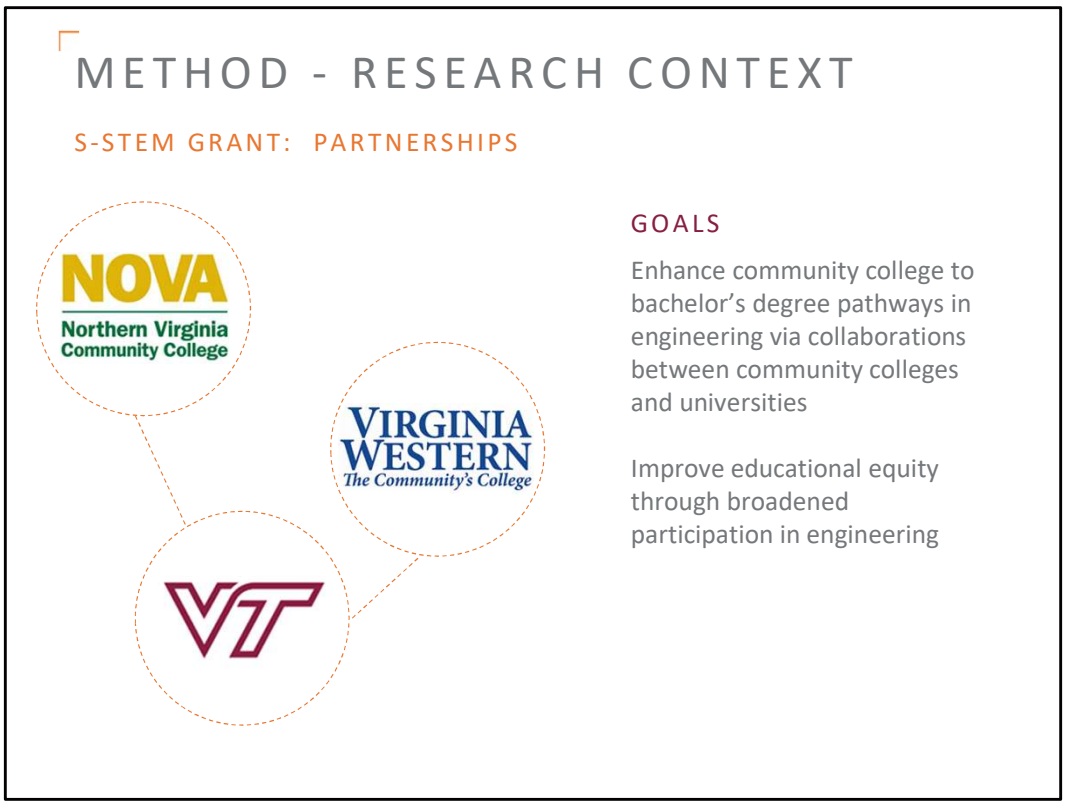
Note. Adapted from Advancing a New Critical Framework for Transfer Student Research: Implications for Institutional Research: Advancing a New Critical Framework for Transfer Student Research, by F.S. Laanan & D. Jain, 2016, New Directions for Institutional Research, p. 16.

The logic of this study is derived from Laanan and Jain's (2016) Conceptual Model of Studying Diverse Transfer Students and Organizational Contexts as shown in the slide. This model allows researchers to consider a wide range of factors as they investigate the transfer phenomenon for a diverse range of transfer students. It combines transfer, cultural, and social capital with Transfer Receptive Culture (TRC).

There are four primary elements within the framework, each of which we operationalize in this study:

1. **Background Characteristics.** DTSOC begins with students and recognizes that all students possess assets that enhance the institution. For this study, we operationalize Inputs as credit earned before community college enrollment. This credit includes, for example, credit earned via AP testing, CLEP testing, dual enrollment, military service, or from other colleges.
2. **Community College.** The community college environment is split into three subcategories: academic performance, academic experiences, and transfer student capital (TSC). Both individual and organizational aspects of the pre-transfer experiences have a significant impact on credit loss. This study operationalizes the number of credits completed and associate degree completion. In addition, we consider credits that meet the AS degree requirement and those that do not. We also group developmental coursework (ESL, math, and English) with precalculus to consider the "warm-up" needed to start an engineering degree.
3. **University.** The university environment is split into three subcategories: institutional characteristics, academic performance and experiences, and social experiences. University characteristics and policies govern a great deal of how transfer credits are accepted and applied. In addition, institutions' characteristics and academic performance can dictate the number of credits accumulated at the university; this element also impacts credit loss. We operationalize the number of credits accepted and applied.

4. **Student Outcome Measures**. Different outcomes should be considered to understand how students are progressing through transfer and to their degree. Examples of outcomes include GPA, academic ability, attitudes, beliefs, and values. In this study, we use credit loss as an outcome measurement because it relates to college affordability, which is of particular importance to the engineering transfer student population.

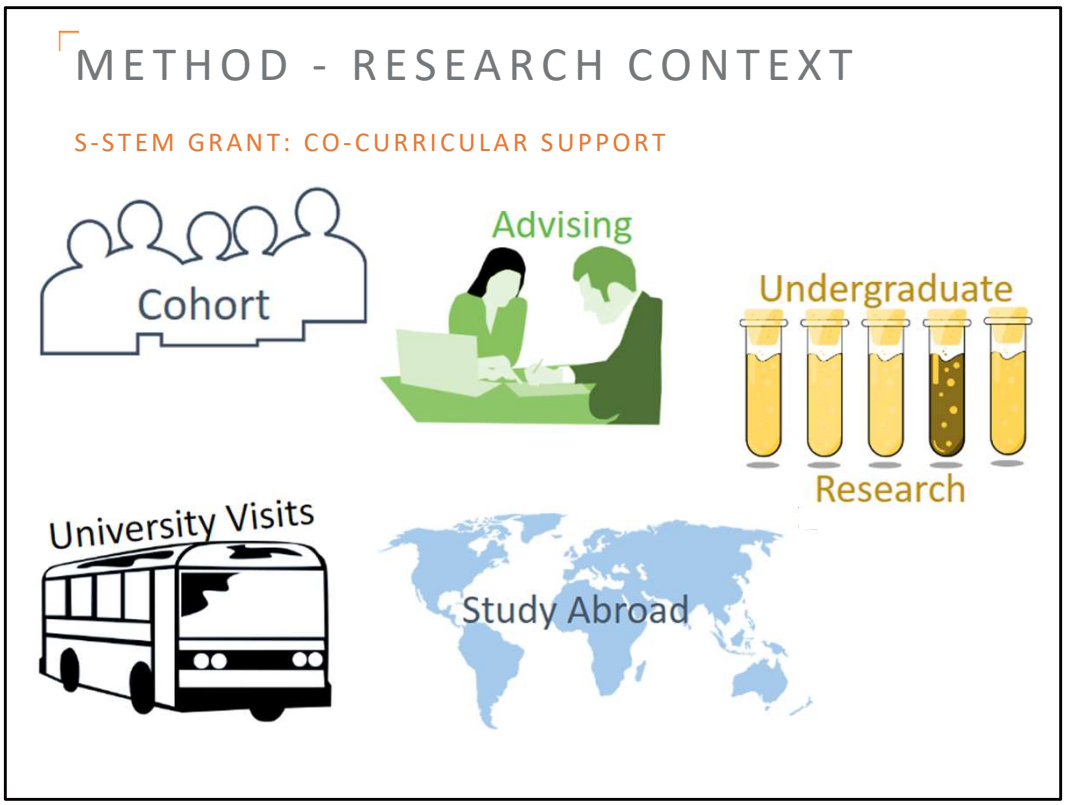


This study focuses on participants in a National Science Foundation funded S-STEM grant. The S-STEM grant in this study is a collaboration between Northern Virginia Community College (NVCC), Virginia Western Community College (VWCC), and Virginia Tech (VT).

- NVCC is the largest public educational institution in Virginia, with over 75,000 students, and it is the second-largest community college in the United States.
- VWCC currently enrolls over 8,500 students in credit courses and is close in geographic proximity to VT.
- VT is a large public research-intensive university where engineering is the largest college and enrolled 9,385 students in 14 different engineering disciplines in 2021.

NVCC and VWCC were partners for this grant because these institutions transfer the most students to the College of Engineering at VT.

NVCC and VWCC are institutions within the Virginia Community College System (VCCS). There are 23 community colleges that comprise the VCCS and have a guaranteed admission agreement with VT's College of Engineering. This agreement requires VCCS students to earn an associate degree in Engineering with a GPA of at least 3.2. In addition to this agreement, there are many articulated engineering courses between the two institutions to help reduce credit loss. Finally, Virginia Tech has a policy that waives the general education courses if a student earns the AS degree from a VCCS school. The guaranteed admissions agreement, articulated engineering courses, and the general education waiver aim to ease the transition from a VCCS institution to VT. Limiting this analysis to this group of participants removes any variation in credit acceptance policies (i.e., only one receiving institution) and institutional differences (i.e., both sending institutions offer the same courses and operate under the same state system).



The program not only provides funding for scholarships but also curricular and co-curricular opportunities that have been shown to support student success in STEM as described in Grote, et.al (2022).

- **Cohort.** Students were required to attend monthly meetings that were led by community college faculty. The meeting agenda always included a portion on advising and transfer process and the remaining portion of the meeting were planned around student interests such as: study skills, resume writing, interviewing, choosing an engineering discipline and research opportunities. Every meeting also included a meal where students could catch up and socialize with each other.
- **University Visits.** During the fall semester students in the program were invited to spend the weekend at VT for the University's Open House. Students were introduced to the university and the surrounding area along with meeting other prospective transfer students as well has transfer students that have successfully transferred to VT. In the spring semester S-STEM community college students were invited for the weekend to participate in the College of Engineering's Open House. This event allowed student to interact with faculty and students in every engineering disciplines.
- **Advising.** Each student in the program was intrusively advised. Community college faculty advisors in partnership with general engineering advisors at VT and the student created a curricular plan to minimize credit loss. The advising process was intentionally collaborative so students could gain "design" experience by understanding the parameters and reviewing the course taking options. Student's progressed was tracked and plans were updated if a change was necessary.
- **Study Abroad.** S-STEM students had the opportunity to participate in a 2-week study abroad experience. This was paid for by the grant. In total 63 students elected to participated in this program after their first year. This short-term study abroad was an existing program at VT and the S-STEM students were added to it. This allowed the S-STEM students to interact with their first-time-in-college peers in addition to experiencing engineering in an international context.

- **Undergraduate Research.** The S-STEM students were given the opportunity to apply for a summer research opportunity the summer prior to transfer. This experience allows students to work closely with engineering faculty and graduate students on an ongoing research project. Students are provided with housing and paid a stipend for the summer. This experience intentionally provides an opportunity for students to establish a network at VT prior to starting classes while gaining familiarity with the institution and surrounding area.

METHOD - PARTICIPANTS

		Number of Participants	Percentage of Total
Gender			
	Male	47	78.3%
	Female	13	21.7%
Ethinicity			
	Hispanic, Latino, or of Spanish Origin	9	15.0%
	Not Hispanic, Latino, or of Spanish Origin	51	85.0%
Race			
	Asian	10	16.7%
	Black or African American	11	18.3%
	Native Hawaiian or Other Pacific Islander	1	1.7%
	White	26	43.3%
	Two or more races	5	8.3%
	Other	7	11.7%
Engineering Discipline			
	Aerospace	4	6.7%
	Biological Systems	1	1.7%
	Biomedical	2	3.3%
	Chemical	4	6.7%
	Civil	8	13.3%
	Computer	3	5.0%
	Computer Science	11	18.3%
	Electrical	10	16.7%
	Industrial Systems	5	8.3%
	Material Science	1	1.7%
	Mechanical	9	15.0%
	Ocean	2	3.3%
Community College			
	Northern Virginia	43	71.7%
	Virginia Western	17	28.3%

Participants in an S-STEM grant (n = 60).

- US Citizen
- Full-time students - at least 12 credits per semester
- Financial need as demonstrated by FASFA

The student participants in the S-STEM grant had to meet three qualifications:

- must be a U.S. citizen
- must show financial need as demonstrated by their FASFA
- must be a full-time student. As of Fall 2022, 104 students have participated in the grant, with 60 successfully transferring to VT (refer to Table demographic information).

These students represent an "ideal" transfer case as they were intrusively advised and formed a cohort to build their TSC to increase participants' likelihood of successfully transferring.

METHOD - DATA SOURCES

Term	Loc.	Subject	Numb	Cred	Gra	Change.Maj	AS.D	Path.	P.C.Xfe	P.C.Deg.I	C.Xf	C.Deg.R	VT.Major
201708	AP	HIS	111	3	T	0	0	0	3	0	3	0	EE
201708	AP	HIS	112	3	T	0	0	0	3	0	3	0	EE
201708	AP	HIS	121	3	T	0	0	0	3	0	3	0	EE
201708	AP	HIS	122	3	T	0	0	0	3	0	3	0	EE
201801	NVCC	EGR	195	3	A	0	0	0	0	0	0	0	EE
201801	NVCC	PED	116	1	A	0	0	0	0	0	0	0	EE
201708	AP	ECO	202	3	T	0	1	1	0	0	0	0	EE
201708	AP	ECO	201	3	T	0	1	1	0	0	3	0	EE
201708	CLEP	HUM	201	3	T	0	1	1	0	0	0	0	EE
201708	CLEP	HUM	202	3	T	0	1	1	0	0	0	0	EE
201708	NVCC	SDV	100	1	A	0	1	1	0	0	0	0	EE
201801	NVCC	EGR	265	4	A	0	1	0	3	0	3	0	EE
201806	NVCC	EGR	255	1	A	0	1	0	1	1	1	1	EE
201901	NVCC	EGR	206	2	B	0	0	0	2	2	2	2	EE
201708	NVCC	EGR	120	2	A	0	1	0	2	2	2	2	EE
201806	NVCC	EGR	295	3	A	0	1	0	2	2	2	2	EE
201708	AP	CSC	201	4	T	0	0	0	3	3	3	3	EE
201801	NVCC	MTH	285	3	A	0	0	0	3	3	3	3	EE
201801	NVCC	MTH	291	3	A	0	0	0	3	3	3	3	EE
201708	CLEP	ENG	111	3	T	0	1	0	3	3	3	3	EE
201708	NVCC	CST	110	3	A	0	1	0	3	3	3	3	EE
201801	NVCC	EGR	251	3	A	0	1	0	3	3	3	3	EE
201806	NVCC	EGR	126	3	A	0	1	0	3	3	3	3	EE
201806	NVCC	EGR	252	3	A	0	1	0	3	3	3	3	EE
201708	NVCC	ENG	112	3	A	0	1	0	3	3	3	3	EE
201801	NVCC	MTH	277	4	A	0	1	0	3	3	3	3	EE
201708	AP	MTH	273	5	T	0	1	0	4	4	4	4	EE
201708	AP	PHY	231	5	T	0	1	0	4	4	4	4	EE
201708	NVCC	CHM	111	4	A	0	1	0	4	4	4	4	EE
201708	NVCC	MTH	174	5	A	0	1	0	4	4	4	4	EE
201801	NVCC	PHY	232	5	A	0	1	0	4	4	4	4	EE
201808	NVCC	PATHWAY	0	0	0	0	0	0	16	16	16	16	EE

We created a database that contains all the course information from the community college transcript. For each **community college transcript**, the following information was collected for each attempted course:

- Semester the course was taken
- Source of the credit such as AP, CLEP, Dual Enrollment, military, other colleges, etc.
- Subject and course number
- Number of credits
- Grade earned

Community College Advisement Report:

- If the course was used to meet the AS degree requirements
- If the course was a general education course (Pathway) that was required for the AS degree, which then qualifies the student for the Pathway Waiver at VT
- Change of Major

VT Transcript:

- If the course was accepted to the University
- The number of credits the equivalent VT cousre is. This number was equal to or less than the original number of credits.
- Engineering discipline
- Change of major

VT Advisement Report

- If the accepted course was applied to the student's degree
- If the general education (pathway) waiver was used

METHOD - CALCULATED QUANTITIES

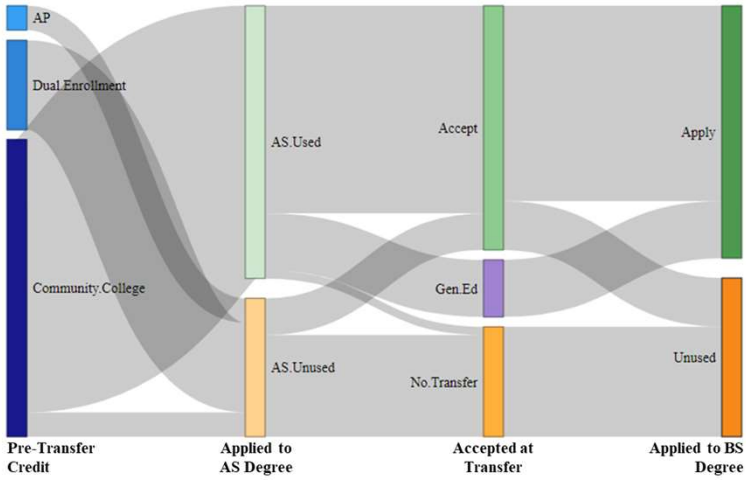
Name	Source	Description
CC_Credit_All	CC Transcript	Total number of community college credits attempted
CC_Credit_Pass	CC Transcript	Total number of community college credit that student earned a grade of C or better
CC_Credit_Fail	CC Transcript	Total number of community college credit that student earned a grade of D, F, P-, or U
CC_Credit_Withdraw	CC Transcript	Total number of community college credit that student earned a grade of W
AS_Used	CC Transcript	Total number of pre-transfer credits used to meet an AS degree requirement.
AS_Unused	CC Transcript	Total number of pre-transfer credits that were not used to meet the AS degree requirement.
Outside	CC Transcript	Total number of credits earned outside and accepted by community college. These credits include AP, CLEP, NYU Exam, ABLE Exam, Dual Enrollment, and Other College credits transferred into the Community College
CC_WarmUp	CC Transcript	Courses taken at Community College that were pre-requisites to program requirements. These include ESL, developmental math and English, and precalculus.
VT_Accept	VT Degree Audit	Total number of pre-transfer credits accepted by Virginia Tech
VT_Apply	VT Degree Audit	Total number of accepted credits applied to the degree at Virginia Tech
Pathway	CC Transcript	Total number of credits taken pre-transfer that were used to meet the Pathway credit waiver

The database was used to calculate the variables in the table. These were used to create Sankey diagrams to visualize credit mobility through transfer.

DATA ANALYSIS

RESEARCH QUESTION

What are the sources of credit loss (e.g., pre-community college, AS degree credit, transfer loss, and applied to degree loss) at transfer for engineering transfer students?



Our research question investigates the sources of credit loss at transfer for engineering transfer students. We created Sankey diagrams for each student to visualize whether pre-transfer credit was applied to the associate degree, was accepted at VT, and was applied to the degree at VT. A sample student Sankey diagram is shown in the slide to illustrate how the Sankey diagrams were created. At each stage, the Sankey provides a visual representation of the sources of credit loss, labeled *Unused*.

- **Leftmost column.** All of the pre-transfer credit passed/earned is categorized on the left side of the Sankey diagram in the slide. Each source category represented on students' community college transcripts was divided into credit that was used to earn the AS degree and credit that was not. Outside credit in this data set included test credits (e.g., AP, CLEP, IB, NYU Language Exam and ABLE exam) and other college credits that were accepted by the community college (e.g., credits from other community colleges, bachelor's degree granting institutions, international institutions, and military credit). In addition to outside credit, the credit that was passed with a C or better at the community college was also categorized into *AS.Used* and *AS.Unused*. The last source of pre-transfer credit included in this data consist of dual enrollment courses. The NVCC and VWCC transcripts clearly note when courses were taken at these institutions as part of a dual enrollment agreement while a student was in high school.
- **Second Column from the Left.** The second set of bars from the left show whether the pre-transfer credit was utilized to meet an associate degree requirement (*AS.Used*) or not applied to the associate degree (*AS.Unused*).
- **Third column from the Left.** Flows from the second set of bars toward the third set of bars categorize credits in three ways: VT accepted credit (*Accept*), general education waiver credit (*Gen.Ed*), and credit that did not transfer between institutions (*No.Transfer)*. The accepted credit was obtained from the student's VT transcript. Credits in the *Gen.Ed* category are present for students who earned the AS degree at the time of transfer. These credits come from general education courses that were

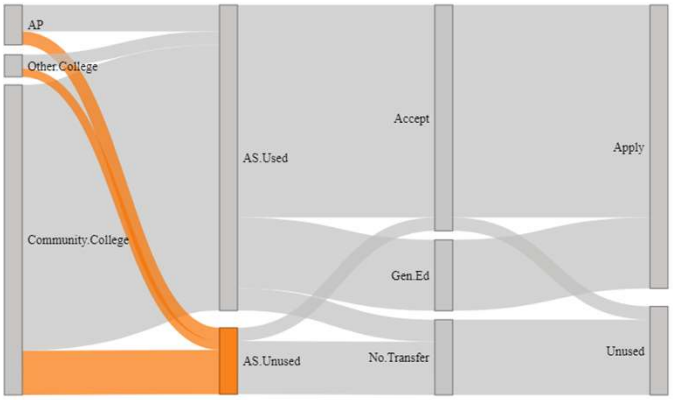
used to meet an AS degree requirement that subsequently were waived at VT as a component of the general education waiver policy.

- **Rightmost Column.** Flows from the third set of bars toward the final set of bars on the right were then divided into credit that was applied to students' BS degree at VT (*Apply*) and credits that were *Unused*. A student's VT degree audit report was used to determine if the accepted credit was used to meet a degree requirement. The accepted and unused credit could be used to meet Free Elective credit requirements if applicable for a particular bachelor's degree requirement. VT used alphabetical order of course subject codes to determine which course was used to fulfill that degree requirement (i.e., if there were multiple courses from which to choose). Because the Free Elective credit is populated prior to earning the bachelor's degree, it is not clear at the time of transfer whether a transfer course or a VT course would be used to meet this requirement. Because of this uncertainty, all accepted credits that were not applied to a stated degree requirement were moved to *Unused*, and none were used to meet a Free Elective requirement.

All students in the dataset experienced *Unused* credit.

- Minimum = 4
- Maximum = 71
- Mean = 25.1
- Median = 22

SOURCES OF CREDIT LOSS



SOURCE	% SEGMENT
AP	12.9%
CLEP	1.3%
Dual Enrollment	9.9%
Other College	10.3%
Community College	65.5%

PRE-TRANSFER CREDIT TO ASSOCIATE DEGREE UNUSED

The Sankey in this slide represents one student. The Table represents all students in the sample.

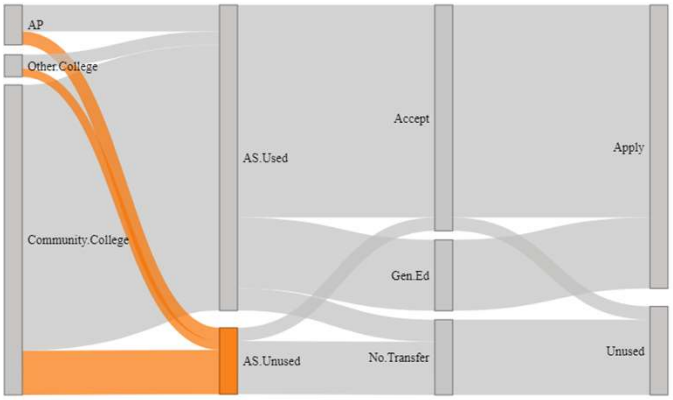
We investigated each connection in the Sankey diagrams to compile a list of *AS.Unused* credit for each source of pre-transfer credit. A sample Sankey of one particular student shown in the slide highlights in orange the connections under investigation in this part of the results.

- 30% of students in the sample took **AP** credit during high school, and 89% of those students lost some or all this credit. The credits students earned by AP but were not used in the AS degree were largely in social sciences, including economics, history, government, and psychology. Some of the English and math credits are requirements in the AS degree, but students chose to retake those classes at community college, and therefore would appear as an unused source of credit. Although VCCS schools are required to accept a score of 3 or higher on the AP exam, VT only accepts scores of 4 or 5. Students who earned a score of 3 would earn credit for the course at the community college and could take the subsequent course following transfer to VT, but they would need to retake the course since their AP score would not meet a BS degree requirement. Thus, students would often elect to retake courses that would have otherwise been waived at the community college from the AP exam.
- Taking a **CLEP** language exam allows students to use prior knowledge, such as English as a second language, to earn college credits toward an AS degree. The CLEP credits that were unused were all 100-level French and Spanish courses. The students who earned these credits took the CLEP test to earn 200-level Language credits that meet the 6 credits of Arts/Humanities needed for the associate degree. The 100-level courses that were not used were awarded with the 200-level Language courses.
- **Dual Enrollment** credits that were earned but not used to meet an AS degree requirement include a large amount of social science credits, such as government and history courses. In our sample, 47% of VWCC students earned dual enrollment credit.

Of the 47% of students who earned dual enrollment credit, 88% lost some or all these credits in the transfer process. In contrast, 12% of students from NVCC earned dual enrollment credit, and 20% of those students lost this type of credit. There are only 6 credits (2 courses) of social sciences required to earn the AS degree, and many students took an excess of that amount as part of dual enrollment programs. There were also a large number of technical courses, such as architecture, computer aided drafting, finance, and medical terminology, that were offered as part of a dual enrollment program that were not used to meet an AS degree requirement

- Credits that **transferred from other colleges** varied in nature. These unused courses were similar to dual enrollment as there were students who transferred in pre-calculus and 100-level language credit to prepare them to start the Engineering AS program. There were courses such as English, general chemistry I, and circuits that would meet an Engineering AS degree requirement at NVCC. However, the students chose to retake those classes at the community college because Virginia Tech would not have accepted that prior credit based on not having an articulation agreement in place with the original credit source.

SOURCES OF CREDIT LOSS



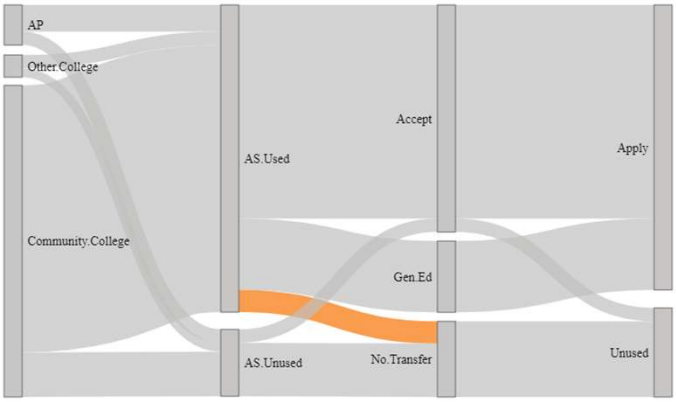
PRE-TRANSFER CREDIT TO ASSOCIATE DEGREE UNUSED

SOURCE	% SEGMENT
AP	12.9%
CLEP	1.3%
Dual Enrollment	9.9%
Other College	10.3%
Community College	65.5%

TYPE	%
Developmental	23.90%
Engineering	13.55%
Math/Science	11.83%
Technical	7.97%
Other	16.53%

Finally, students also accumulated unused credit while they attended **Community College**. The largest portion of those credits were developmental credits, such as English as a second language, developmental English, developmental math, and pre-calculus. Many of the unused engineering courses (26 out of the 56 instances in total) were earned by taking a special course for the S-STEM program that was team-taught with Virginia Tech to prepare students for a study abroad experience. Most of the remaining unused engineering and math courses could have been transferrable to Virginia Tech. However, many students in the S-STEM grant took classes beyond what was required for the AS degree that ultimately did transfer to VT. These extra engineering and math courses are marked as unused for the AS degree but were subsequently categorized as being accepted and applied to the VT bachelor's degree. An important caveat for this scenario is the presence of the scholarship through the S-STEM program. Because students pay by the credit hour in the community college setting, it is possible that the S-STEM grant enabled this additional course taking; students relying solely on other sources of financial aid would not be permitted to enroll in additional courses within financial aid restrictions.

SOURCES OF CREDIT LOSS

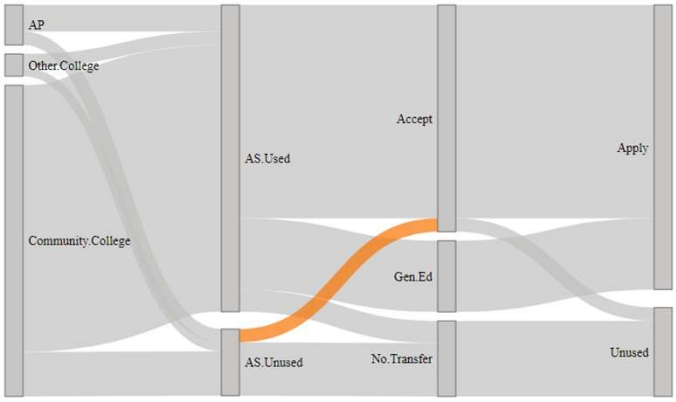


SOURCE	% SEGMENT
Single Credits	74.50%
Entire Course	24.61%

ASSOCIATE DEGREE TO NON-ACCEPTANCE

- Much of the credit loss in this connection from *AS Used* to *No Transfer* are attributed to equivalent courses not having equivalent credit values. An example of this scenario is Calculus III (Introduction to Multivariable Calculus at VT). This required course for an Engineering AS degree and required for every engineering discipline at VT is 4 credits in the VCCS, but the equivalent course is 3 credits at VT. Thus, every student who took this course at the community college experienced 1 lost credit. This scenario is also true for calculus-based physics, a two-course sequence for students who attended NVCC. The two-course sequence totals 10 credits at NVCC, but the equivalent sequence at VT is 8 credits. These single credits can add up for students. For example, a NVCC student in Computer Science would lose 8 single credits, one each for engineering design, computer science I, computer science II, calculus I, calculus II, calculus III, physics I, and physics II. NVCC reduced their calculus I and II classes from 5 credits to 4 credits in Fall 2018, so students who took those courses in more recent semesters would not lose those single credits.
- Students in this sample also lost credits because of non-acceptance of entire courses. In many of these cases the credit was not accepted because the credit equivalencies were for groups of courses for a group of credit, not a one-to-one mapping. For example, in electrical engineering, students needed to take EGR 126, EGR 251, EGR 252, and EGR 255, a total of 10 credits at NVCC, to earn credit for 9 credits of coursework at VT. Because it is important for the credits to equal out, the student would take a 1 credit loss, which equates to the lab (1 credit), so the course did not transfer in. Although the student needed the lab course to complete the grouping, the credit for that course was not used in meeting the degree requirement.

SOURCES OF CREDIT LOSS



SOURCE	% SEGMENT
Partial Course	22.30%
Entire Course	77.80%

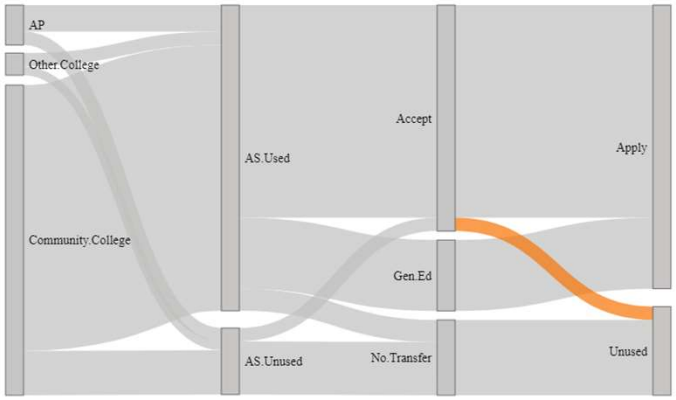
ASSOCIATE DEGREE UNUSED TO ACCEPTANCE AT VT

Although not necessarily credit loss, specifically, we also investigated the sources of credit that were not used to earn the AS degree but were accepted at VT.

- Most of the partial credit that was not used to meet an Engineering AS degree requirement but was accepted at VT linked to pre-calculus. The pre-calculus course in the VCCS is 5 credits, and there is an equivalent course at VT that is 3 credits. Although this course is accepted at VT from the perspective of transfer credit, it is not used in any of the engineering disciplines.
- Most of the entire courses that were not used for the AS but were accepted at VT were math and science classes. Math classes not used for the AS degree included linear algebra, differential equations, and discrete math, which many engineering disciplines require at VT.

Credits that were unused for the AS degree but were accepted and applied at VT are problematic. These credits would not be covered by financial aid since they did not meet an AS degree requirement, but the courses were accepted at the point of transfer. Fifty-six percent of community college students receive some type of financial aid (AACC, 2022). Differential access to such classes could represent an inequity among engineering transfer students. The students in this study received an S-STEM scholarship to offset the additional cost of these classes. This option is not a likely alternative for students solely relying on financial aid. The credits that did not meet the AS degree requirements but were still accepted at VT were often because of a change of major, an error in class selection prior to participating in the S-STEM grant, or using pre-community college credit in the elective space when those specific courses would not be in the intended engineering discipline. Specific advising strategies, resources, and changes to financial aid regulations would help make these types of credit less problematic.

SOURCES OF CREDIT LOSS

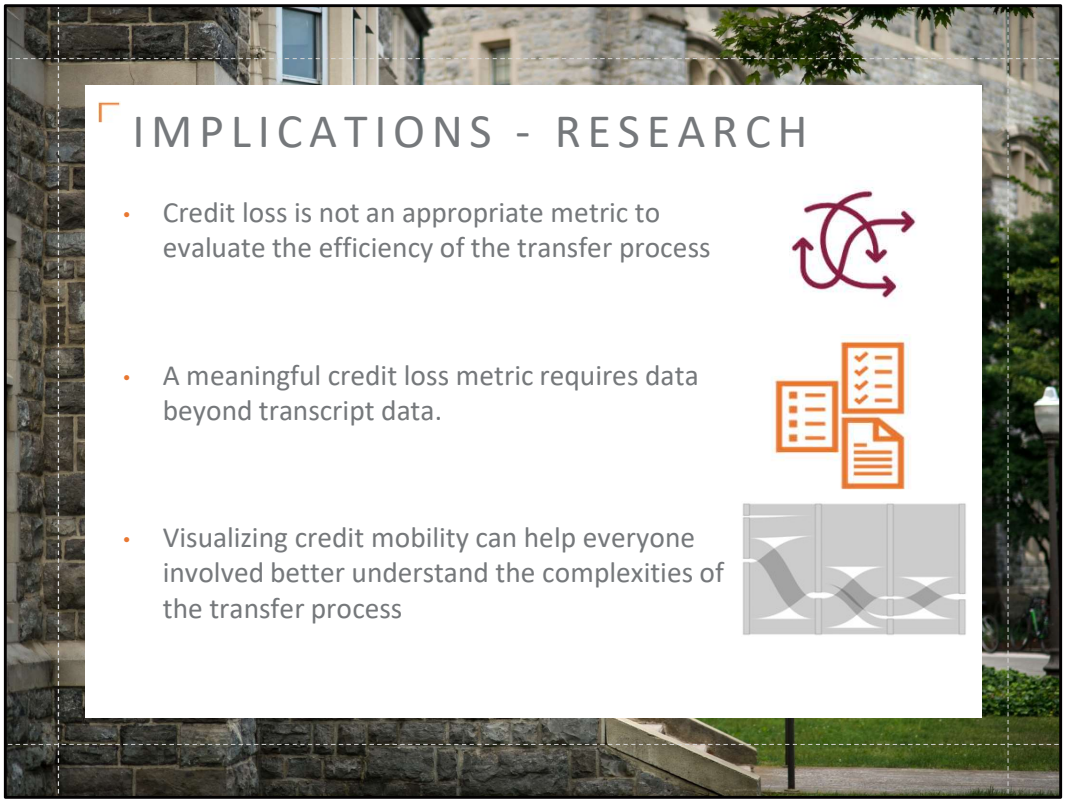


SOURCE	% SEGMENT
Arts/Humanities/Social Science	27.42%
Engineering	31.43%
English/Communication/Language	4.22%
Math	24.00%
Science	10.86%
Technical	2.00%

ACCEPTED AT TRANSFER TO NOT APPLIED TO BS DEGREE

The final segment that contributes to credit loss for an engineering transfer student is from *Accepted* to *Applied*, shown highlighted in orange in the slide. These are courses with a VT equivalent but are not required for a student's particular engineering discipline. The credits comprising this connection for the 60 engineering transfer students are compiled in the Table in the slide.

Some of the Engineering courses that were accepted by VT but not applied to students' degree requirements were required for the VWCC degree, including a programming course and a statics course. Such courses are accepted at VT but not included in the requirements for every engineering discipline. In addition, if a student changed their engineering discipline during their time at community college, they likely took a course that would be accepted by VT but not applied to their particular degree program. Half of the math classes in this category were pre-calculus; as previously mentioned, this course is accepted by VT but not required for any engineering discipline. Much of the remaining math classes were differential equations. This course is required for both VWCC and NVCC (after 2018) but is not needed for Computer Science students at VT. Arts/Humanities, English/Communications, Language, and Social Science classes also show up in this segment for students who earned the AS degree but took more than the required number of classes in these categories. Because the General Education classes are waived due to the student earning the AS degree, these extra classes were accepted but not needed for the bachelor's degree.



Credit Loss not an appropriate metric in and of itself

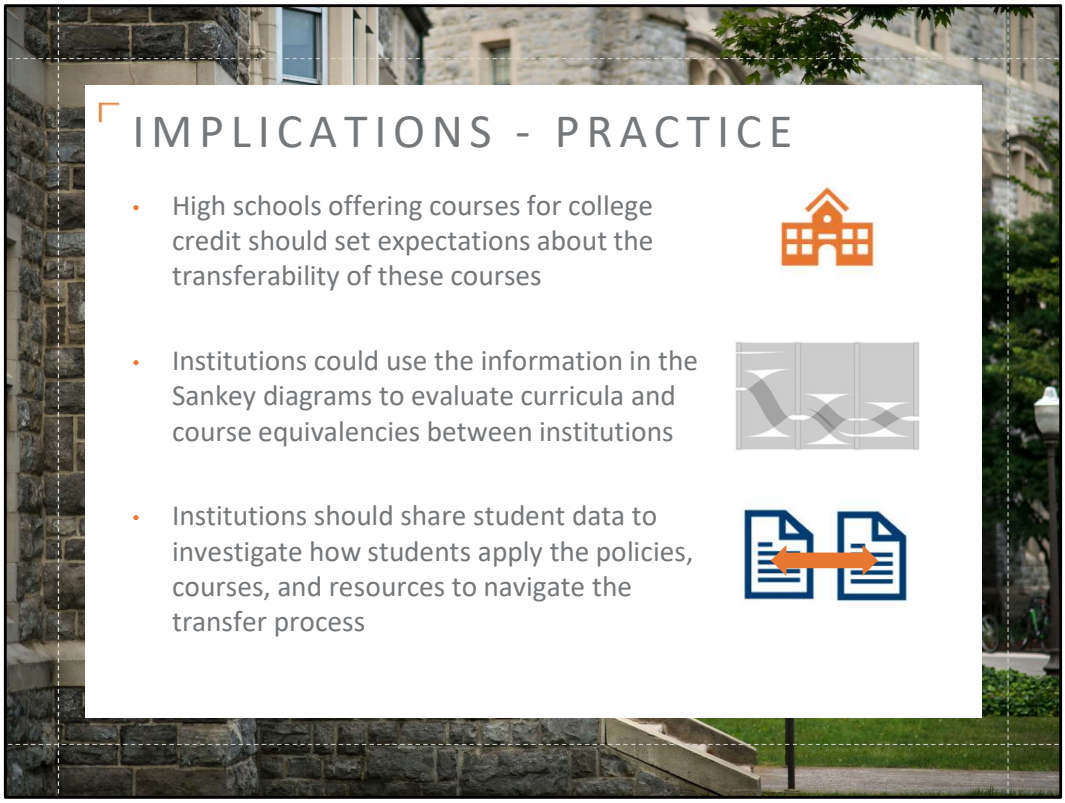
- There are many sources of credit loss that are not attributed to transfer.
- Not all credit loss is bad as some students need warm-up credit such as pre-calculus to enter the engineering degree pathway
- Students refer to courses not credits. There is a difference when talking to students between, “you need 120 credits to earn a degree” and, “you need this set of courses to earn the degree.” The language of credits linked to college credentials does not provide the specificity needed. In the case of single credits lost because of the credit discrepancy between sending and receiving institutions, the number of courses lost is a more appropriate metric than credit loss—the single credit cases do not communicate meaningful information. Although credits are easier to calculate for researchers, course loss may be a better match for students’ understanding.

Data Beyond Transcripts

- Credit loss is complex and highly nuanced.
- There is no way to provide reasons for credit loss with just transcript data.
- Finding a way to share and automate this data collection at postsecondary institutions is critical in calculating a meaningful credit loss metric.

Credit Mobility Visualizations

- These show how complicated moving post-secondary credit.
- The students in the second phase represent the “ideal” case – highly advised and considering one transfer institution. Despite these ideal conditions, the diagrams are still complex. This complexity amplifies when students change majors, accumulate postsecondary credits from multiple sources, and consider multiple receiving institutions with varying degree requirements and course transfer equivalencies.
- If we authentically want to improve the transfer process, we must embrace and address this complexity in parts. By breaking down credit mobility this way would allow researchers to delve deeper



Postsecondary Credits in High School

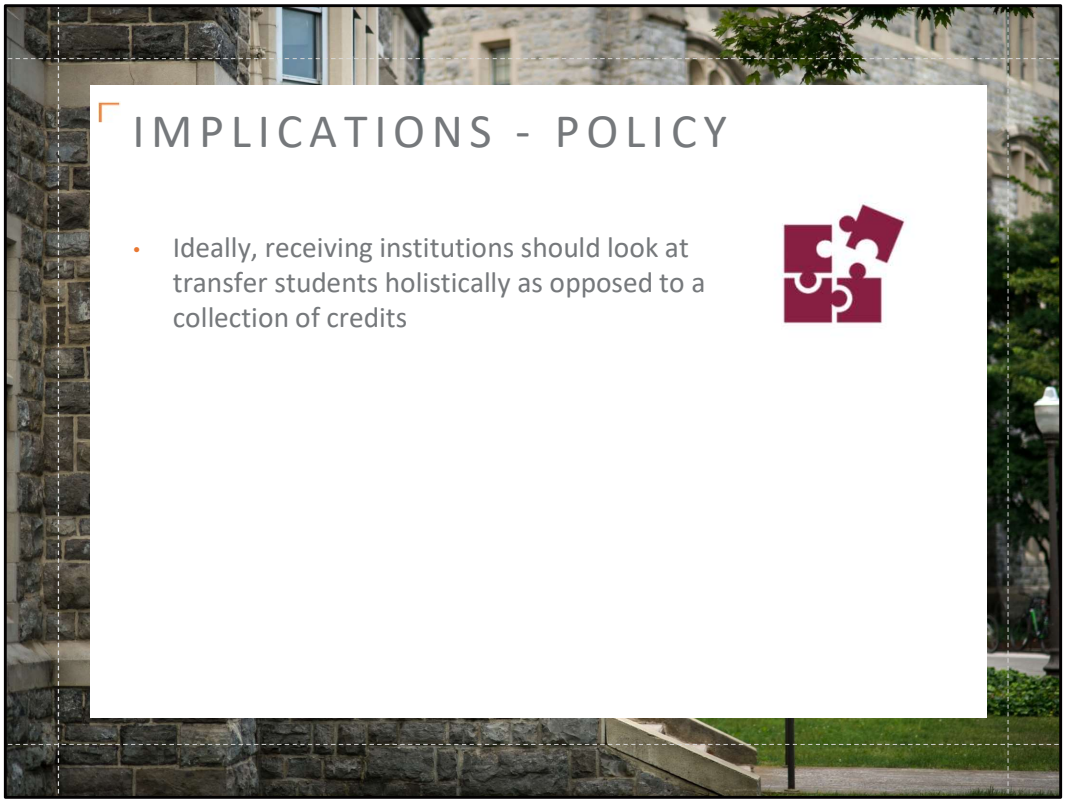
- One stated benefit of AP courses is getting a jump start on college and reducing time to degree
- If we genuinely want to reduce time to degree, we need to be intentional and transparent about the college courses offered as part of a high school degree.

Sankey to Evaluate Curricula

- This visualization helps faculty, advisors, and administrators throughout the system clearly see the parts of credit loss that fall within their sphere of influence.
- Institutions can use these credit loss segments to examine how students navigate and make course choices in their programs.

Share Student Data

- The data for this study was made available because of an S-STEM grant between institutions. Other avenues to share student data, such as degree audit reports, should be explored to understand student practices better.
- This type of data sharing is essential in increasing our understanding of the need to improve transfer student outcomes (Wyner et al., 2019).



Trasnfer Students Holistically

- For example, if an engineering student earns a 3 on an AP Calculus AB exam, which gains them credit at the community college, then goes on to pass Calculus II, Calculus III, Differential Equations, and Physics, should they have to retake Calculus I post-transfer because they didn't earn a score of a 4 on the AP exam?
- Institutional policy on credit acceptance should allow for this type of holistic review.

SCOPE AND LIMITATIONS

SINGLE INSTITTUION

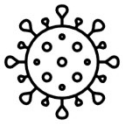
- Reduce variability in credit acceptance and degree requirements.
- Reduces generalizability

INTRUSIVE ADVISING

- Likely credit loss is underestimated

PANDEMIC DISRUPTION

- Impacts course taking patterns & student performance
- Impacts degree progression and time to degree



Single Institution

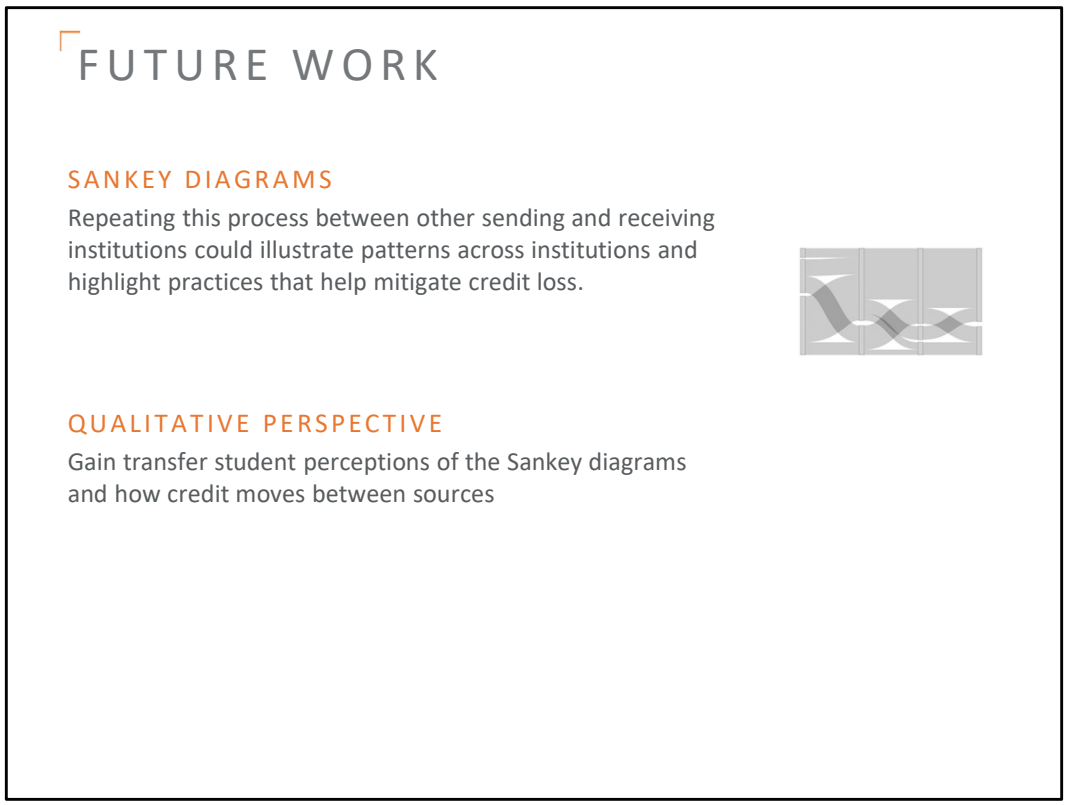
One presumes that the credit loss will be low because of an articulation agreement and strong partnership between the institutions. By starting with this presumed ideal condition, we were able to highlight the importance of addressing credit loss. Results at a high level could be translated to similar institutions with articulation agreements and partnerships. Further studies need to be conducted on other types of transfer or vertical transfer from non-articulated institutions, and my work should be replicated at other similar institution, but this study will provide a blueprint that other institutions could follow using their own data.

Intrusive Advising

A key component of this project is that each student was intrusively advised. Likely, the credit patterns described here underestimate credit loss at the time of transfer for most engineering transfer students who were not provided this type of course-taking advising. In addition to underestimating the magnitude of credit loss, the Sankey diagrams would likely look different for students that were not advised in this manner.

Pandemic Disruption

Data for phases two and three were collected between 2017 and 2022, with most students transferring in Fall 2020. We made every effort to note when circumstances related to COVID-19 affected a student if they are readily apparent. It is also unclear the extent to which the COVID-19 disruption will continue to be felt by future cohorts.

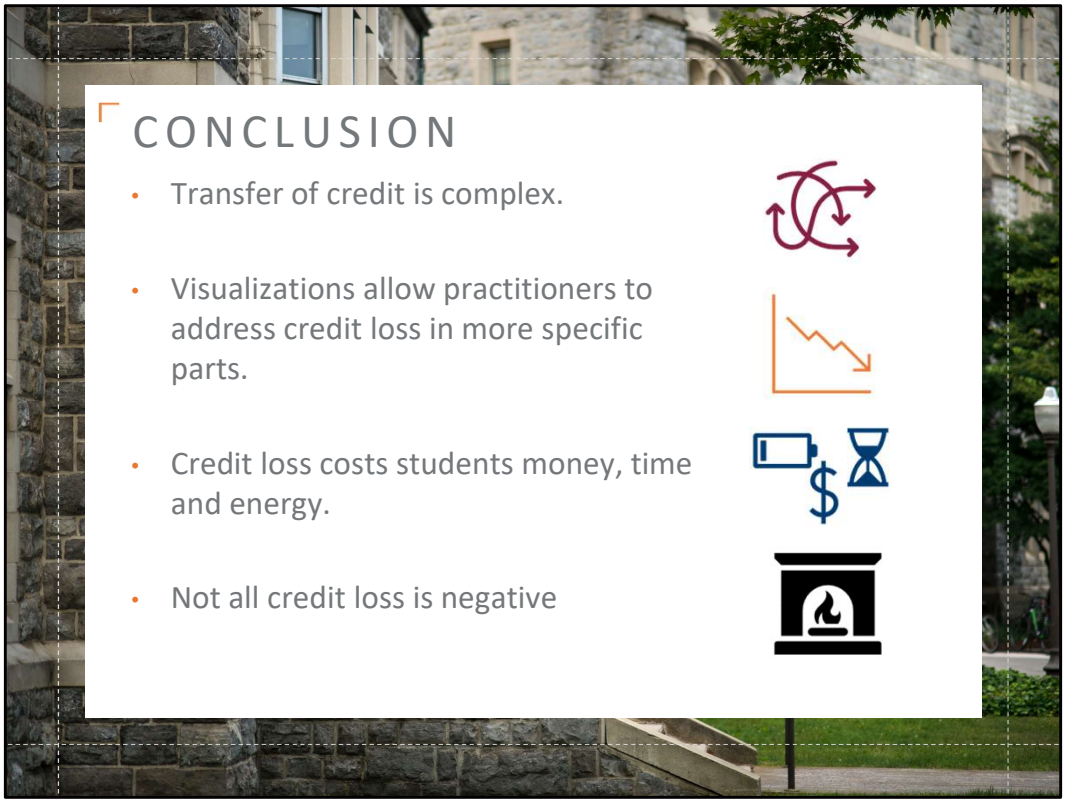


Sankey Diagrams

The students in this study were heavily advised while attending the community college. Recreating the Sankey diagrams for vertical engineering transfer students that did not have the same advising resources would illuminate the impact of advising. Additionally, repeating this process between other sending and receiving institutions could illustrate patterns across institutions and highlight practices that help mitigate credit loss. In addition to the credit mobility visualization, adding date ranges to the Sankey diagrams to contextualize the amount of time it took a student to accrue credit would add insight into course-taking patterns. Adding the timing variable would allow for work to be done to see if credit loss varies across time. One argument for reducing credit loss is to mitigate the cost of earning a bachelor's degree by reducing the time a student attends a post-secondary institution (Jenkins & Fink, 2015). Examining the relationship between credit loss, time to degree, and cost would be helpful.

Qualitative Perspective

Other potential future work involves gaining transfer student perceptions of the Sankey diagrams and how credit moves between sources. This type of investigation would provide a deeper understanding of the transfer process for engineering students from their perspective. Previous work on vertical transfer student decision-making point to the transferability of credit as an essential factor when considering transfer options (Wickersham, 2020). Accessing student perspectives and understanding of credit mobility can provide insight into decision-making behaviors. This type of study could also reveal misconceptions students have regarding credit mobility.



Transfer is complex.
Our findings indicate that anytime a student has a chance to earn post-secondary credit they also run the risk of losing that credit.

Sankey Diagrams
The Sankey diagrams not only show that students earn excess credits from all types of sources but allow all stakeholders to address credit loss in more specific parts. We anticipate that these new visualizations can help "bring to life" this issue in new ways, which will be useful in advancing policy and practice conversations. Historically, conversations around credit loss can often involve finger pointing and placing blame at high schools, community colleges, and receiving institutions. However, this study shows that there is more work for everyone that offers post-secondary credit to mitigate excess credit accumulation.

Credit Loss Costs
If the credit is not transferred into VT, causing the students to take more classes and lengthen the time to degree, the costs could be higher. Not to mention the opportunity costs of delaying earning the degree.

Credit Loss is Not All Negative
There are sources of credit loss that could be reframed as credit assets. One of these sources of credit loss was post-secondary credits earned as part of a high school degree, such as AP and Dual Enrollment. The experience of taking these courses may benefit the students in other ways, such as college readiness and higher persistence rates; however, this is not how the courses are marketed to high school students. Additionally, developmental coursework was a large source of unused credits for engineering transfer students. The students who took these credits ended up transferring and were successful post-transfer. We am not arguing the legitimacy of developmental education but instead how much math-readiness is deemed important for beginning an engineering degree. It is time for engineering programs to re-examine the weight they put on math readiness at the point of matriculation. If we genuinely want to increase STEM graduates and broaden

participation in engineering, engineering needs to embrace students who earn warm-up credit.


QUESTIONS?