AERA Open
January-December 2024, Vol. 10, No. 1, pp. 1–15
DOI: 10.1177/23328584241289377
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Earned Credit Could be Lost Credit

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Beginning the path to a bachelor's degree in community college has the potential to be a more cost-effective higher education option. Previous research on transfer students has focused broadly on curriculum alignment, articulation policies, and academic advising in efforts to reduce credit loss. Credit loss can significantly impact transfer students and result in unnecessary time and costs for them. Minimal research quantifies and visualizes credit loss or explains in detail how and why it occurs throughout students' entire education trajectories. This study visualizes credit loss for bachelor's programs seeking engineering transfer students who began at in-state community colleges using data from the sending and receiving institutions. Findings revealed that credit loss can occur throughout the entire degree pathway, including high school dual enrollment and advanced placement credits to community college credits. This work has implications for informing degree pathways and policies that promote successful transfer and degree completion.

Keywords: *community colleges, engineering education, higher education, curriculum, descriptive analysis, credit loss, transfer students, excess credit, Sankey diagram, credit mobility*

Introduction

Most students enter community college intending to transfer and earn at least a bachelor's degree. However, only 25% of students actually transfer within 5 years, and only 17% earn a bachelor's degree (Horn & Skornsvold, 2011; Jenkins & Fink, 2015). The students who ultimately transfer from a community college to a university perform as well as first-time college students who begin their education at the receiving institution (Glass & Harrington, 2002; Melguizo et al., 2011). For example, one study using National Student Clearinghouse data found that 76% of transfer students ultimately graduate at the most competitive institutions compared with 75.5% of first-time college students at those same institutions (Glynn, 2019). Although most students who ultimately transfer are successful in earning their bachelor's degree, a significant percentage is still not successful after transfer, and a larger group of community college students who had intended to transfer and earn a bachelor's degree ultimately did not follow that path. Thus, much more work needs to be done to realize the potential of the transfer pathway. The engineering pathway in particular has been described as long and inefficient, with calls for more focused work on engineering coursework and transfer policies to improve student success (Blash et al., 2012). For the transfer pathway to be a viable option for engineering students, we need to know more about course sequencing between sending and receiving institutions, the transfer pathways that successful transfer students take, and student performance after transfer (Grote et al., 2020; Ogilvie, 2014; Smith & Van Aken, 2020).

One of the issues at the heart of successful transfer pathways is the mobility of credits across institutions—moving credits from one institution to another is a critical process for the transfer pathway to be a viable option (Jenkins & Fink, 2015; Monaghan & Attewell, 2015; Wyner et al., 2019). Most transfer students experience at least some credit loss, but little is known about the factors—both student-related and institutional factors—that most contribute to this loss (Giani, 2019). Furthermore, there is a difference between credits that transfer to an institution versus credits that are applied toward a degree. Focusing on this distinction is an area in need of further investigation given its implications on students' time to degree and college affordability.

Credit loss is a broad term that refers to credits not accepted by a receiving institution previously earned by the student (Giani, 2019), revealing an inefficiency in the transfer system. Credit loss is an even more critical issue for transfer students enrolled in highly sequential degrees, such as engineering. Missing one required prerequisite course at the time of transfer can set a student back a year or more. Grote et al. (2020) demonstrated at one large research institution that engineering transfer students lag in time to degree compared with students who did not transfer. Determining what credits transfer in engineering could help ease the transfer process, improve graduation rates, and broaden participation in engineering.

Our study examines credit mobility of engineering transfer students in a comprehensive manner that extends what we know about engineering transfer student credit loss specifically, as well as conceptualizations of credit loss more broadly. We use transcript and degree audit reports from both sending and receiving institutions to map a student's credit usage and loss. Additionally, we quantify and disaggregate credit loss to assist transfer agents at all institutions to address the sources of credit loss. Our study builds on previous research on credit loss by deepening our understanding of the factors that lead to the accumulation of excess credits.

Relevant Literature and Conceptual Framework

Measuring Credit Loss

Prior research on measuring credit loss for transfer students is limited and depends greatly on available data, and this often produces limitations and omissions. Three types of credit-loss quantities have been measured in prior studies: credit transferability, credit applicability, and excess credits among completers. *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 that widespread credit loss among transfer students impacts their graduation prospects (Monaghan & Attewell, 2015). Credit transferability varies across states and demographic factors, emphasizing the contextual nature of the issue (Giani, 2019).

Credit applicability refers to the number of transfer credits used to meet a degree requirement. This metric is challenging to assess because of data constraints, but it is crucial in understanding the effectiveness of the transfer pathway. In one study, researchers found that 83% of pretransfer credits were accepted by the university, yet only 70% of pretransfer credits were actually applied to the degree (Texas Higher Education Coordinating Board, 2001). The measure for 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 with their nontransfer counterparts (Fink et al., 2018; Xu et al., 2016). The literature agrees that transfer students earn excess credits, but there is no indication of the sources of this loss. Our study builds on this research on credit loss by investigating how credit flows to, through, and from community colleges through transfer.

Influences on Credit Loss

Although research on credit loss for engineering transfer students is limited, factors contributing to credit loss, including curriculum, policies, and advising, have been studied in prior work. The path to a bachelor's degree in engineering tends to be more straightforward for students who start at a bachelor's degree–granting institution. The path for a transfer student is not as clear because these students must navigate the curricula of two different institutions and try to find as much similarity as possible across institutional contexts. Prior work on curricular complexity found that engineering programs have highly complex curricula with high variation across engineering disciplines (Grote et al., 2020) and even within the same discipline across multiple institutions (Heileman et al., 2019). For engineering transfer students, this variation makes choosing transferable courses confusing and complicated, particularly if a student is uncertain about their choices of discipline and transfer institution.

To aid credit mobility, 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). In their analysis of 34 statewide articulation agreements, Taylor and Jain (2017) found that even though the agreements facilitate the transfer of credits from associate degrees to be used for a bachelor's degree, the focus tends to be on general education core courses and not major-specific courses. In engineering programs, major-specific courses are highly sequential, so missing a course or taking a class that does not meet transfer criteria could delay students' progress to a degree.

Academic advising at community colleges shares information with students about curricula, both at the community college and at the university, and policies to guide students to a successful transfer. Hayes et al. (2020) used a qualitative case study to examine the role of community college and university advisors in helping students gain transfer knowledge. They found that academic advising can positively and negatively affect transfer student outcomes. Wang et al. (2021) used a longitudinal survey of just over 1,000 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. Expanding on previous research, Brawner and Mobley (2016) focused on advising experiences of engineering transfer students by analyzing student interviews across five institutions. Although this study reinforces prior assertions that pretransfer 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. Thus, academic advising is vital for engineering transfer students to navigate the complex curriculum, apply transfer policies, and adhere to articulation agreements.

In summary, the literature on engineering transfer students around curriculum, policies, and advising discussed credit loss as a barrier to successful transfer and degree completion. According to a recent call to action to enact exemplary credit applicability practices, 53% of transfer students who attained a bachelor's degree did not have all their transfer credits applied toward their degree (Scaling Partners Network, 2020). This inefficiency in degree attainment disproportionately impacts community college students, primarily Black and Hispanic students (NSC Research Center, 2018)—the net result is a transfer pathway that has not been optimized, which translates into increased financial costs and time for students.

Conceptual Model of Studying Diverse Transfer Students and Organizational Contexts

Laanan and Jain's (2016) conceptual model of studying diverse transfer students and organizational contexts (DTSOC) provides the framework for this study. By integrating elements of student-focused transfer, cultural and social capital, and transfer-receptive culture, DTSOC facilitates a holistic exploration of the transfer phenomenon. The model comprises four main elements, each operationalized in the study:

- *Background characteristics (inputs).* This element emphasizes students' unique attributes, encouraging institutions to view students as assets to and leverage their diverse backgrounds. Our study operationalizes this element by considering credits earned before community college enrollment.
- *Community college environment.* The community college environment encompasses academic performance, academic experiences, and transfer student capital. Our study operationalizes this element by considering variables such as the number of credits accumulated at community college and the number of credits accepted at the university.
- *University environment.* The university environment involves institutional characteristics, academic performance, academic experiences, and social experiences. Our study operationalizes this element by examining variables such as the number of credits accepted and applied at the receiving institution.
- *Student outcome measures (output).* This element assesses various outcomes to understand students' progression and success, such as grade-point average, academic ability, and attitudes. Our study operationalizes this element by investigating credit loss at transfer as an outcome measurement, focusing on credit mobility throughout a transfer student's education.

The DTSOC model highlights the interconnectedness of the community college and university environments in fostering a *transfer-receptive culture* (Jain et al., 2011) that supports transfer students throughout their postsecondary journey. The model underscores the importance of both the sending and receiving institutions' commitment to transfer students even before their enrollment at the university. We adopt this view to explore credit mobility and identify potential ways to mitigate credit loss for engineering transfer students.

Although prior studies found that vertical transfer students experienced credit loss in some form, there are no indications of the specific sources or timing of this credit loss. In this study, we provide insight into the sources of credit loss at the time of transfer. Additionally, our research expands beyond traditional credit-loss calculations to distinguish between accepted and applied credits. We address the following research question:

- What are the magnitude and sources of credit loss (i.e., pre–community college, associate of science [AS] degree credit, transfer loss, and applied-to-degree loss) for engineering transfer students?

Methods

Research Setting

Data for this study were drawn from 60 student participants in a National Science Foundation–funded S-STEM grant. The S-STEM grant in this study is a collaboration between two community colleges and one university. One of the community colleges is the largest public education institution in the state, with >75,000 students, and it is the second-largest community college in the United States. The other community college currently enrolls >8,500 students in credit courses and is located near the research university. The research university is a large public research-intensive institution where engineering is the largest college and enrolled 9,385 engineering students in 14 different engineering disciplines in 2021. The two community colleges were partners for this grant because these institutions transfer the most students to the College of Engineering at the research university. This partnership provides a unique opportunity to follow students through the transfer process from the start of their community college journey through their bachelor's degree.

The student participants in the S-STEM grant had to meet three qualifications: (1) they must be a U.S. citizen, (2) they must show financial need as demonstrated by their Federal Student Aid (FASFA) form, and (3) they must be a full-time student. As of the fall 2023, 124 students had participated in the grant, with 60 transferring to the partner university (Table 1 provides demographic information). Students who did not transfer to the partner university followed a range of paths, including transferring to a wide range of other universities (Hernandez et al., 2024). The S-STEM grant participants were consistently advised by both community college faculty advisors and partner university advisors throughout

TABLE 1
Participant Demographics

Factor	No. of participants	Percentage of total participants	Fall 2023 engineering transfer percentage at university	Fall 2023 total engineering percentage at university
Gender[a]				
Male	46	76.7%	85.0%	77.7%
Female	14	23.3%	15.0%	22.2%
Ethnicity				
Hispanic, Latino/a, or Spanish origin	9	15.0%	8.1%	9.6%
Not Hispanic, Latino/a, or Spanish origin	51	85.0%	91.9%	90.4%
Race				
Asian	10	16.7%	20.1%	16.5%
Black or African American	10	16.7%	4.6%	5.0%
White	27	45.0%	49.2%	53.3%
Two or more races	5	8.3%	4.8%	4.9%
Other	8	13.3%	21.3%	20.3%
Engineering discipline				
Aerospace and ocean	6	10.0%	9.9%	11.8%
Biological systems	1	1.7%	0.8%	1.7%
Biomedical	2	3.3%	2.3%	3.2%
Chemical	4	6.7%	2.8%	3.7%
Civil	8	13.3%	9.6%	9.3%
Computer	3	5.0%	7.1%	9.9%
Computer science	11	18.3%	32.7%	23.3%
Electrical	10	16.7%	8.6%	5.6%
Industrial systems	5	8.3%	2.5%	8.2%
Material science	1	1.7%	1.0%	1.9%
Mechanical	9	15.0%	21.1%	17.8%
Other	0	0.0%	1.5%	3.6%

[a]As researchers, we problematize the collection of gender data in this manner, but we are reporting the variable as collected by the university.

their participation in the grant. In addition to advising, grant participants also could choose to participate in other co-curricular activities described in Grote et al. (2022), including university visits, study abroad, and undergraduate research. These students represent an ideal transfer case because they were proactively advised and formed a cohort to build their transfer student capital in an effort to increase participants' likelihood of successful transfer.

The two community colleges sit within a broader state community college system that includes 23 community colleges that all have a guaranteed admissions agreement with the College of Engineering at the university. This agreement requires community college students to earn an Engineering AS degree with a grade-point average 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, the university has a policy that waives the general education courses if a student earns the AS degree from a community college within the system. The guaranteed admissions agreement, articulated engineering courses, and general education waiver aim to ease the transition from the community college to the university. Limiting our 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).

Sample, Data Collection, and Data Analysis

Individual student transcripts from both the sending and receiving institutions are needed to understand credit loss with precision. Prior credit-loss calculations (Fink et al., 2018; Giani, 2019; Jenkins & Fink, 2015; Monaghan & Attewell, 2015) do not account for the credits accepted by an institution that did not ultimately meet a degree requirement in a particular program. We analyzed the S-STEM students' transcripts for each participant from the community colleges and combined those with degree audit reports from the research university. Both sets of transcripts and degree audit reports must be used to quantify credit loss accurately.

Data collection took place in several stages. The first step was to create a database containing all course information from the community college transcripts. For each community college transcript, the information in Table 2 was collected for each

TABLE 2
Information Collected from Community College Transcripts for Each Course

Name	Description
Semester	The semester the course was attempted
Source	Where the credit was earned, such as community college, AP, CLEP, dual enrollment, military, other college(s), etc.
Subject	Subject code
Number	Course number
Credits	Number of credits in the course
Grade	Grade earned (A, B, C, D, F, W, I, P, PF, S, or U)
AS degree	Marked if the course met a degree requirement for the Engineering AS
Pathway	Marked 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 the College of Engineering.
Change of major	Marked if the student changed their major while at community college

attempted course. The semester, subject code, course number, number of credits, and grades were directly entered from each student's transcript. The source of the credit on the student's transcript was noted to account for Advanced Placement (AP), College Level Examination Program (CLEP), dual enrollment, military, Adult Basic Learning Exam (ABLE), and other college credits. Once the data from each transcript were collected, those courses were compared with the student's community college degree audit report to determine whether the course was used to meet an Engineering AS degree requirement.

After the community college transcript and degree audit report data were compiled, each course was compared with the credit evaluation on the degree audit report at the research university to determine how many credits were accepted. This number was equal to or less than the original number of credits. Additionally, students' engineering discipline, change of major status, and minor were noted. Finally, the degree audit report was analyzed to determine which of the accepted courses were applied to the student's degree.

Data analysis consisted of compiling, cleaning, and calculating each segment of credit flow, which we present in tables in the *Results* section. We created Sankey diagrams to visualize how pretransfer credit was applied to the associate degree, accepted at the research university, and applied to the bachelor's degree. Sankey diagrams communicate the flow of resources, which in this case is accumulated academic credits (Stafford, 2020).

Results

In this exploratory quantitative study, we provide an overview of the overall magnitude of credit loss, followed by a comprehensive analysis of its underlying sources for the 60 engineering participants. We investigated three stages of the transfer process to determine the sources of credit loss. First, we examined all credits earned before transfer, including outside credits and credits earned at the community college. This data set's outside credits include test credits (e.g., AP, CLEP, International Baccalaureate, and ABLE) and other college credits accepted by the community college (e.g., credits from other community colleges, bachelor's degree–granting institutions, international institutions, and military credits). The last source of pretransfer credits we included consists of dual enrollment courses. In addition to outside credits, we also included the credits that a student passed with a C or better at the community college. We categorized all these pretransfer credits as either meeting an AS requirement or going unused. The second stage of credit loss occurs at the point of transfer to the university. At this stage, we categorized all pretransfer credits into three groups: receiving institution–accepted credits, general-education waived credits, and credits that did not transfer between institutions. We obtained the accepted credits from the receiving institution's degree audit report. Credits that were waived applied to students who earned the AS degree at the time of transfer; these credits came from general-education courses used to meet an AS degree requirement that were subsequently waived at the receiving institution as part of the articulation agreement. Finally, the third stage involved assessing how the accepted credits at the university were applied to the student's bachelor's degree requirements, which we determined using the student's degree audit report.

We quantified credit loss at each of the three stages (i.e., pretransfer, transfer to university, and applied to degree); descriptive statistics are listed in Table 3, and the distribution of total unused credits appears in Figure 1. The mean value of total credit loss was 25.10, and the median was 22. The range of total credits lost was 67 with a maximum value of 71 credits. This maximum represents multiple years of lost credits and tuition, with this total more than the number of credits needed for an associate degree.

Putting the mean value in terms of academic enrollment, this result suggests that, on average, students experienced more than one semester of credit loss amounting to >$4,000 in tuition and fees in community college terms or >$7,500 in university terms. Additionally, we disaggregated total credit loss by gender, ethnicity, race, engineering discipline, and community college, as seen in Table 3. We recognize that gender is not binary and can be fluid, but we were limited to the available institutional data for our analysis. We found that total credit loss did not vary appreciably by different groups of students; we observed the greatest variation between engineering disciplines for this sample.

Pretransfer Credit

We compiled a list of unused credits for each source of pretransfer credit. The total number of credits earned, used,

TABLE 3

Total Credit Loss by Transfer Stages and Student Groups

Total credits unused	n	Mean	SD	Median	Min	Max
Three stages of transfer						
Pretransfer unused credits	60	19.38	14.13	15.5	0	66
Credit loss at transfer	60	19.14	12.17	16.5	4	62
Total unused credits	60	25.10	14.52	22	4	71
Gender						
Male	14	22.81	17.08	20	4	71
Female	46	25.80	13.79	22.5	5	68
Ethnicity						
Hispanic, Latino/a, or Spanish origin	9	23.22	9.48	27	11	40
Not Hispanic, Latino/a, or Spanish origin	51	25.44	15.29	21	4	71
Race						
Asian	10	23.40	11.92	23.5	8	41
Black or African American	10	19.40	12.90	17.5	5	44
White	27	27.00	29.31	23	11	71
Two or more races	5	5.00	20.00	9.67	4	27
Other	8	8.00	23.38	8.75	13	38
Engineering discipline[a]						
Aerospace and ocean	6	35.05	10.26	34.6	24	51
Civil	8	17.25	12.78	12	4	40
Computer science	11	35.18	19.14	29	14	71
Electrical	10	18.20	6.53	18	8	28
Industrial systems	5	26.4	11.15	26	13	38
Mechanical	9	21.56	9.02	19	12	39
Other	11	23.91	16.62	18	5	62
Community college						
CC#1	43	23.47	13.68	23	4	71
CC#2	17	29.25	16.16	21	8	62

[a]Disciplines with fewer than five students were combined in the "Other" category.

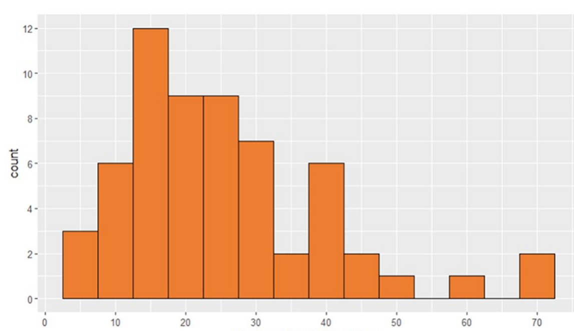

FIGURE 1. *Histogram of total credit loss for the sample.*

and unused by type of pretransfer credit is summarized in Table 4; these credits are categorized in 10 areas: arts/humanities, developmental, engineering, English/communication, language, math, science, social science, student development, and technical. Table 5 provides the number of instances in which loss occurred, the unique courses within each category, the percentage of unused credits attributed to the category, and the number of students within the sample who were impacted.

The credits students earned from the AP exam 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 for the AS degree, but students chose to retake those classes at community college, and therefore, such instances would appear as an unused source of credits. Although schools in the community college system are required to accept a score of 3 or higher on the AP exam, the receiving institution 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 the university, but they would need to retake the course because their AP score would not meet a BS degree requirement. Thus, students often would elect to retake courses that otherwise would have been waived at the community college from the AP exam. Science courses for which AP credits were earned but not used for the

TABLE 4

Pretransfer Credits Earned, Used, and Unused

Pretransfer credits	No. of students	Total no. of credits earned	No. of credits used	No. of credits unused	Percentage of unused credits
AP	16	246	115	131	53.3%
CLEP	5	46	30	16	34.8%
Dual enrollment	10	186	93	93	50.0%
ABLE	3	3	3	0	0.0%
Other college	11	203.28	101.64	101.64	50.0%
Community College	60	4386	3643	743	16.9%

TABLE 5

Sources of Credit Loss by Transfer Stage

Source and course subject	No. of instances of lost courses	Unique courses	Percentage of unused credits
From pretransfer credit to associate degree			
AP (12.9% unused)			
English/communication	10	4	2.5%
Language	4	4	1.3%
Math	6	4	1.7%
Science	7	4	2.3%
Social science	18	11	4.4%
Technical	2	2	0.7%
CLEP (1.3% unused)			
Language	4	4	1.3%
Dual enrollment (9.9% unused)			
Developmental	3	2	1.2%
Engineering	9	6	1.6%
English/communication	2	2	0.5%
Science	5	3	1.6%
Social science	11	4	2.7%
Student development	1	1	0.1%
Technical	9	7	2.2%
Other college (10.3% unused)			
Arts/humanities	5	5	1.1%
Developmental	3	3	0.9%
Engineering	3	3	0.4%
English/communication	4	4	0.8%
Language	4	4	1.2%
Math	4	4	1.3%
Science	6	6	1.9%
Social science	5	5	1.2%
Student development	1	1	0.1%
Technical	9	6	1.4%
Community college (65.5% unused)			
Arts/humanities	9	7	2.2%
Developmental	68	16	23.9%
Engineering	56	14	13.6%
English/communication	7	4	1.7%
Language	4	4	1.2%
Math	29	24	8.8%

(continued)

TABLE 5 (CONTINUED)

Source and course subject	No. of instances of lost courses	Unique courses	Percentage of unused credits
Science	9	7	3.0%
Social science	9	8	2.2%
Student development	8	2	0.9%
Technical	37	15	8.0%
From associate degree to nonacceptance at transfer			
Single credits (74.5% unused)			
Engineering	68	11	20.9%
Math	85	4	26.2%
Science	89	5	27.4%
Entire course (24.61% unused)			
Engineering	18	11	15.7%
English/communication	4	4	3.7%
Language	1	1	0.9%
Math	3	3	3.1%
Student development	5	2	2.2%
Courses accepted at transfer but not applied to BS degree			
Arts/uumanities	5	4	4.3%
Engineering	43	11	31.4%
English/communication	2	2	1.7%
Language	3	3	2.5%
Math	28	6	24.0%
Science	10	5	10.9%
Social science	27	11	23.1%

Note. This table disaggregates credit loss first by transfer stage (e.g., pretransfer to associate degree, associate degree to nonacceptance at transfer, and courses accepted at transfer but not applied to the bachelor's degree) and then by subject of each course. The number of instances of credit loss that occurred and the number of unique courses in each subject are detailed here. Additionally, the percentage of unused credit per transfer stage is quantified for each course subject.

engineering associate degree included biology and algebra-based physics courses.

Taking a CLEP language exam allows students to use prior knowledge 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 earned but not used to meet an AS degree requirement include a large number of social science credits, such as government and history courses. There are only 6 credits (2 courses) of social science 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. Science dual enrollment courses that were not used to meet an AS degree requirement include biology and the second course in a chemistry sequence. The engineering dual enrollment courses in this sample were special topics courses that did not align with courses in the AS degree plan.

Credits that transferred from other colleges varied in nature and spanned the 10 subject-matter categories. These unused courses were similar to dual enrollment credits because biology and algebra-based physics were not used in the science category. The technical courses included computer-aided drawing, information technology, and fitness. Some courses, such as English, general chemistry I, and circuits, would meet an Engineering AS degree requirement at one community college. However, the students chose to retake those classes at the community college because the university would not have accepted that prior credit based on not having an articulation agreement in place with the original credit source.

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

Point of Transfer

The next source of credit loss is at the point of transfer when students' transcripts are evaluated. The credits that make up this transfer stage for the 60 engineering transfer students are categorized into five of the 10 previously mentioned areas: engineering, English/communication, math, science, and student development. The sources of this loss can be described in two groups: (1) loss in single credits, where the credit-hours earned pretransfer are more than those of the equivalent course at the university, and (2) entire course credits that did not transfer. These sources of credits are compiled in Table 5.

Much of the credit loss in this stage is attributed to equivalent courses not having equivalent credit values. An example of this scenario is calculus III (introduction to multivariable calculus). This required course for an Engineering AS degree and for every engineering discipline at the university provides 4 credits in the community college system, but the equivalent course is 3 credits at the university. 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 one of the community colleges. The two-course sequence provides a total of 10 credits at the community college, but the equivalent sequence at the university provides only 8 credits. These single credits can add up for students.

Students in this sample also lost credits because of nonacceptance of entire courses. In many of these cases, the entire course appears to not have been accepted but was needed for transfer. This can happen when a course is not a one-to-one equivalency but part of a group-to-group equivalency. This course was needed to fulfill the group, but the total group credits were not equivalent, so it appears that one course was not accepted. For example, in electrical engineering, students needed to take a four-course grouping for a total of 10 credits at the community college to earn 9 credits of coursework at the university. 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 at the point of transfer. Although the student needed the lab course to complete the grouping, the credit for that course was not used in meeting the degree requirement.

Applied to Degree

The final transfer stage that contributes to credit loss for an engineering transfer student occurs when credits accepted by the university are applied to the student's bachelor's degree requirements. These are courses with a university equivalent but are not required for a student's particular engineering discipline. The credits comprising this connection for the 60 engineering transfer students are categorized in eight of the 10 previously mentioned areas: arts/humanities, engineering, English/communication, language, math, science, social science, and technical. These sources of credit are compiled in Table 5.

Some of the engineering courses that were accepted by the university but not applied to students' degree requirements were required for the AS degree at one of the community colleges, including a programming course and a statics course. Such courses are accepted at the university 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 the university but not applied to their particular degree program. Half the math classes in this category were precalculus; as mentioned previously, this course is accepted by the university but not required for any engineering discipline. Much of the remaining math-related credits involved differential equations. This course is required for both community colleges (after 2018) but is not needed for computer science students at the university. 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. The general education classes are waived for students earning the AS degree program because of the articulation agreement, so these extra classes were accepted but not applied to the bachelor's degree.

Credit Mobility Visualization

To visualize a student's credit mobility through the three stages of the transfer process, we constructed a Sankey diagram from the transcript/degree audit report dataset for each of the 60 participants to visualize credit mobility. A Sankey diagram depicting the mean pretransfer credit flow applied to a BS degree is shown in Figure 2. All pretransfer credits are represented in the leftmost bars and then divided into credits that were used to earn the AS degree (*AS.Used*) and credits that were not used (*AS.Unused*). The orange connections represent the pretransfer credits that were not used to

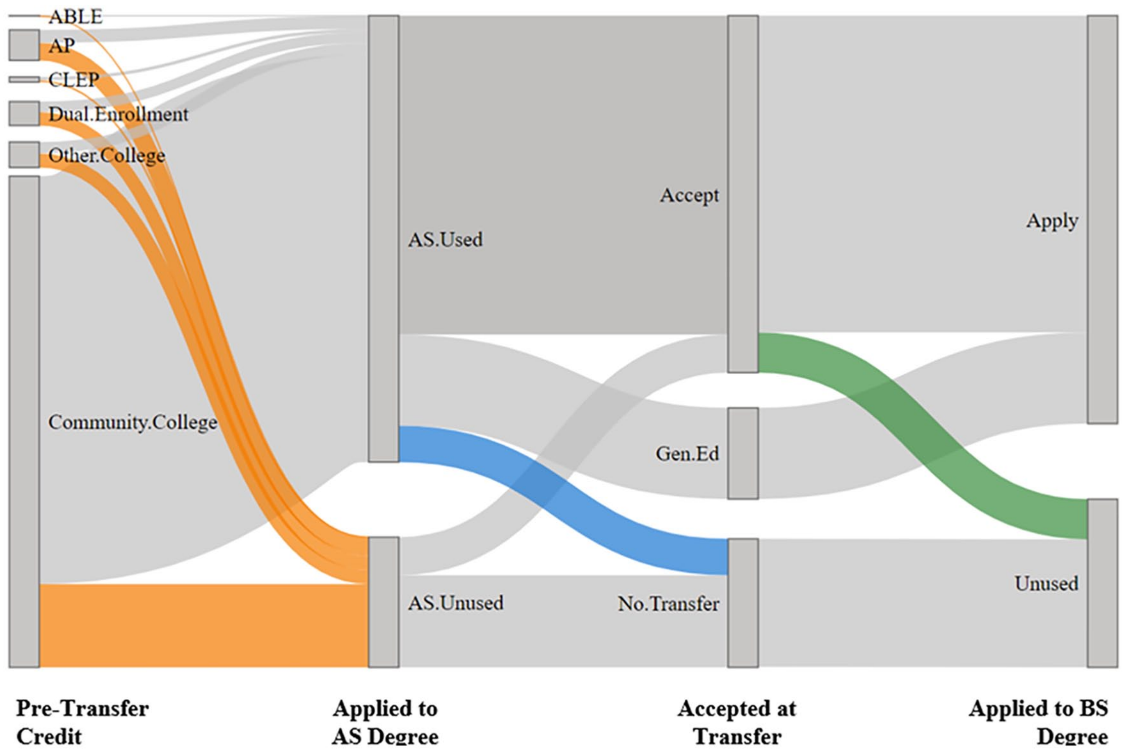

FIGURE 2. *Sankey diagram depicting the mean pretransfer credit flow applied to a BS degree.*

meet an associate degree requirement, the first transfer stage. Flows from the second set of bars toward the third set of bars categorize credits in three ways: (1) receiving institution accepted credits (*Accept*), (2) general education waived credits (*Gen.Ed*), and (3) credits that did not transfer between institutions (*No.Transfer*). The blue-highlighted segment in Figure 2 represents the credits used for the Engineering AS degree that were not accepted at the university. Flows from the third set of bars toward the final set of bars on the right were then divided into credits that were applied to students' bachelor's degree (*Apply*) and credits that were unused (*Unused*). Credits that were lost in the third stage of transfer are represented in green in Figure 2.

Discussion

Our research question investigates the magnitude and sources of credit loss for engineering transfer students. We found that even among this highly advised sample of students, on average, more than one semester's worth of credits was lost, with many students having significantly higher numbers of credits lost than this. The sources of credit loss varied and occurred at multiple points across students' postsecondary journeys. Our discussion focuses on these specific sources of credit loss, which moves beyond prior research on credit loss.

Precollege Credits

Postsecondary credits, including AP and dual enrollment credits earned in high school, proved to be a source of credit loss for our participants. In our sample, 30% of students took AP courses during high school, and 89% lost some or all of these credits. One of the community colleges in our study has two dual enrollment programs for area high school and home school students. In our sample, 47% of students from this community college earned dual enrollment credits. Of the 47% of students who earned dual enrollment credits, 88% lost some or all these credits in the transfer process. In contrast, 12% of students from the other community college earned dual enrollment credits, and 20% of those students lost these types of credits. Most of these precollege credits that were not used were in humanities, fine arts, and social science courses. There is a limited number of these types of courses required for STEM degrees, so we anticipate a similar loss in these majors. However, students majoring in non-STEM degrees may be able to use more of these precollege credits. Overall, more than half the AP and dual enrollment credits earned were unused for our participants.

Although these precollege credits have minimal costs to students, they are advertised to help students reduce time to a college degree (Sadler et al., 2010; Thomas et al., 2013). This benefit can only be true if the AP and dual enrollment credits earned are needed for the student's eventual degree. How students are advised about precollege credits depends on their intended major, so students with precollege credits who expect to earn their degree quickly may be disappointed when they learn about the nonapplicability of those credits (Witkowsky et al., 2020). This disappointment may lead to frustration, reduced motivation to enroll in majors that do not accept precollege credits, and inaccurate financial planning for earning their degrees.

Despite credit loss from precollege coursework, the case can be made that this exposure to postsecondary coursework prior to matriculation has positive impacts. Prior research on community college students found that dual enrollment increased college readiness and was associated with higher grade-point averages, higher persistence rates, more attempted credits, and a higher likelihood of college entry without delay (D'Amico et al., 2013; Karp et al., 2008; Kim & Bragg, 2008; Wang et al., 2015). These benefits provide students with academic momentum to persist to degree attainment. However, if the courses do not transfer, the time and monetary investment can be frustrating for students. Wang et al. (2015) called for stronger alignment in dual enrollment courses and the community college curriculum, particularly in STEM fields, when developing these partnerships. Setting students' expectations accurately on the utility of precollege credits is crucial. This transparency may mean clearer messaging within high schools on the likelihood of these courses to transfer and be applied to a bachelor's degree, what scores students need to earn the equivalent postsecondary credits, and what majors actually would allow students to use these credits. Although precollege credits have been found to relate to positive postsecondary outcomes, if not developed and communicated carefully to students, our findings demonstrate significant credit loss for these kinds of credits.

Impacts of Prior Learning Experiences

Our participants' prior learning experiences manifested in several ways, with both positive and negative impacts. For most participants with prior learning experiences, both CLEP and other college credits resulted in a reporting of both credit loss and credit acceptance. For example, students who spoke English as a second language were able to pay $90 to take one CLEP language exam to earn 14 college credits in their native language. However, only 6 of the credits were needed to meet the humanities/fine arts requirement. This is a cheaper alternative than the tuition and fees associated with 6 credits, but financial aid could not be used for the exam fee. The additional cost may be a barrier to students who rely solely on financial aid to fund their education. Additionally, students who changed institutions to the community college were able to use some of their prior college credits to meet degree requirements. For most students, not all the credits earned at another college were used, but all needed to be evaluated to earn the equivalent credits. Three students took advantage of their prior college experience to take the ABLE exam to test out of a first-year experience course. Students who effectively leverage their prior learning experiences benefit from credit-acceptance opportunities, but such opportunities also are accompanied by credit loss.

Conversely, a lack of prior learning experiences led students to take developmental courses (23.9% of all unused credits), which for our sample include English as a second language, developmental math, developmental English, and precalculus courses. Research is mixed on the effectiveness of developmental education and effective placement policies (Bailey, 2009). In this study, 12 students needed developmental math and/or developmental English courses, resulting in 4% unused credits. However, the students in our sample passed their developmental coursework and succeeded in college-level math and English classes. Although developmental courses are not prevalent in our sample, developmental education costs approximately $1.13 billion nationally (Pretlow & Wathington, 2021). These courses are not traditionally used in calculating credit loss for a transfer student because the intent of the courses is to prepare students for college-level material. However, these courses cost the student time and money, and we believe that they should be part of the credit-loss discussion.

Most of the developmental credits come from precalculus in this sample of engineering students; 35 of the 60 students took some version of precalculus at the community college. Although precalculus is a college-level course, it is not included in the Engineering AS degree or needed to meet bachelor's degree requirements in engineering or computer science. Using Beginning Postsecondary Students Longitudinal Study data, 59.3% of students beginning at community college took a remedial math course (Chen, 2016), which means that a much larger percentage of students had to take precalculus before taking calculus I. For majors that do not require calculus, credit loss from developmental courses may be less than our participants experienced.

One way to broaden participation in engineering or similar fields is to examine the potential for precalculus to meet degree requirements in engineering degrees. Not all students have access to higher-level math courses or are pushed to take these classes in high school, and high school–level socioeconomic status is an indicator of how many students take advanced math classes in this state's high schools (Knight et al., 2022). By accepting and applying college-level precalculus courses in engineering degrees, colleges could send a message that an engineering degree can be possible even if students are not initially calculus ready on matriculation.

Community College Credit Loss

There are places in the Sankey diagram that show how the curriculum at the community colleges results in credit loss, specifically credits that were accepted but not applied to the bachelor's degree requirements as well as credits that were not used for the AS degree but were accepted and applied to the bachelor's degree. Creating clear major-specific program maps and programmatic pathways is essential to realize the transfer process's promise (Wyner et al., 2019). Ideally, the AS curriculum at the community colleges would be flexible enough to allow students to choose any engineering discipline and any receiving institution. Practically, this ideal scenario is difficult, because advising is not always mandatory, leading students to choose courses without consulting an advisor (Carlstrom & Miller, 2013). Brawner and Mobley (2016) found that transfer students often self-advise using online resources but find the sites hard to navigate. This finding is supported by Reeping and Knight's (2021) study of web-based transfer information, which found information to be fragmented and written using language that was difficult to understand. Grote et al. (2023) found that there is a disjointed and complex web of information sources available to transfer students. Thus, a flexible engineering curriculum, although ideal from a credit-loss perspective, also can be difficult for self-advised students to navigate. However, if the Engineering AS curriculum is more specific so that students do not have to make course choices, there could be a resulting influence on the applicability of credits. As an example, the Engineering AS curriculum at one community college required programming and statics courses for all engineering students. These courses are not required for all engineering disciplines at the university, however, so students in those disciplines lose credits from being accepted to apply. Balancing curricular flexibility with advising resources is an essential practice for reducing credit loss in vertical engineering transfer students.

Nearly all the students in our sample (57 of 60) experienced single-credit loss because of credit discrepancies on individual courses. This scenario is an area where community college faculty have agency to equate the credits to receiving institutions. Following the time at which students in this sample would have transferred, for example, the community college system has changed the credits for calculus I, calculus II, university physics I, and university physics II to align with receiving institutions across the state (decreasing credits for those courses from 5 to 4 credits). The community college faculty had conversations regarding the remaining courses that have credit discrepancies. In some cases, the community college faculty felt that they needed the extra time to teach the material required for the courses. In the case of engineering courses, the community college courses need to match the learning outcomes of many receiving institutions. To ensure maximum transferability, community college faculty decided to include materials needed for all schools and increase the credit-hour by 1. There are tradeoffs to this decision, however, because community college students pay tuition by the credit-hour. One suggestion from our research illuminating the number of single-credit losses is to revisit the need for all the material in these courses. Can the receiving institutions agree to accept the course if it meets 75% of the learning outcomes, for example? Or can the receiving institution use the excess credit to meet a different degree requirement so that it is not a lost credit?

The expenses associated with unused community college courses, or the loss of single credits, can pose considerable financial and temporal burdens. Although these courses would all be eligible for financial aid because they meet associate degree requirements, students not using financial aid face significant costs, averaging nearly $200 per credit-hour. Identifying strategies to leverage these community college credits after transfer, especially those associated with single-credit losses, could serve as a motivating factor for students to transfer and efficiently complete their bachelor's degree.

Implications

As stated previously, credit mobility is at the heart of successful transfer pathways. The limited literature on quantifying credit loss signals that credit loss is a widespread issue. By scoping this analysis to one field, engineering, with one receiving institution, we can provide rich data that enable explanations and interpretations of the credit-loss sources. Our hope is that this approach for unpacking the complex issue of credit loss can serve as a blueprint for other majors and institutional partners—although our findings likely can inform engineering at other institutions, the approach we apply here is what we see as being most transferable. For example, the Sankey diagrams provide a visualization for credit mobility and a way to quantify credits moving through each stage of the transfer process. Sending and receiving institutions could use the information in such Sankey diagrams to evaluate curricula and course equivalencies between institutions. The Sankey diagrams represent course-taking patterns and how those courses are used or not used to meet degree requirements in individual segments. Institutions can use these credit-loss segments to examine how students navigate and make course choices in their programs. Ongoing inter- and intrainstitutional conversations discussing the transferability of curricula, courses, and policies based on actual student data are crucial to minimizing credit loss. This visualization can help faculty, advisors, and administrators throughout the system see the parts of credit loss that fall within their sphere of influence.

A significant finding of this study is that engineering transfer students accumulate unused credits at many points during their postsecondary education journeys. Each source of credit loss should be examined further to mitigate this loss starting when a student is in high school. High schools offering courses for college credit, such as AP and dual enrollment, should set expectations about the transferability of those credits. The findings of this study indicate that for the students who accumulated these types of credits, a large number ended up unused. In addition to setting student expectations, high schools should inform students of institutional requirements and how these credits could or could not be used. One stated benefit of AP courses is that they reduce time to degree (Sadler et al., 2010). 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.

The mobility of credits has been the impetus for statewide transfer policies (Roksa & Keith, 2008). However, our study shows that more can be done to ease students' burden of excess credits. Ideally, receiving institutions should look at transfer students holistically as opposed to being a collection of credits. By examining institutional credit-transfer policies, receiving institutions could provide much-needed flexibility for transfer students. For example, if an engineering student earns a 3 on an AP calculus exam, which gains them credits at the community college, and then goes on to pass calculus II, calculus III, differential equations, and physics, should they have to retake calculus I after transfer because they did not earn a score of 4 on the AP exam? This type of institutional policy to provide a holistic credit evaluation takes more resources and intentionality; however, following such an approach will save students money, time, and energy. If the goal is to increase the number of engineering bachelor's degree earners and diversify participation in this field, we should take more time to look at policies around credit transferability to evaluate transfer students as a whole instead of as a collection of parts.

Limitations

We acknowledge several limitations associated with the design of this study that should be considered when interpreting our findings. This exploratory quantitative study investigated the sources of credit loss for 60 engineering transfer students who participated in a National Science Foundation S-STEM grant. The findings are tailored to this specific context and may not be directly applicable to every academic setting or field of study. Additionally, we limited this study to one receiving institution, which removes variation in credit-acceptance and degree requirements. However, the focus on a single institution and field limits the generalizability of the specific results to other institutions. As we noted, we would anticipate that these findings would translate most readily to large universities with large engineering programs but acknowledge variation across states in transfer policy arrangements. Nevertheless, our approach offers a systematic method for dissecting credit loss, providing valuable insights for all stakeholders engaged in the evaluation and allocation of postsecondary credits—the approach for understanding credit loss is what we hope can be most transferable from this research.

Data access was enabled by a program that had a partnership between two sending institutions and one receiving institution. A key component of this S-STEM partnership is that each student was extensively advised via an individual plan of study developed by the community college faculty advisor and then reviewed by a general engineering advisor at the research university in an effort to minimize credit loss. Student course progress was tracked, and changes to students' plans were made by this team of advisors as needed. In all likelihood, 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 potentially could look different for students who were not advised in this manner.

Conclusion

The community college pathway to a bachelor's degree has the potential to lower the cost of earning a bachelor's degree. However, this lower cost may not be realized if students lose significant numbers of credits in the process. We focused on engineering transfer students in this study, a field whereby curricular sequencing is particularly important. However, our approach to illuminating sources of credit loss is what we believe is most transferable from our research. Our study advances prior research on credit loss by expanding our understanding of the sources that contribute to accumulating excess credits. The visualizations in this study demonstrate that credit transfers are complex. Our findings indicate that any time a student has a chance to earn postsecondary credits, they also run the risk of losing those credits. The Sankey diagrams not only show that students earn excess credits from all types of sources but also allow all stakeholders to address credit loss in more specific parts. We anticipate that these new visualizations can help bring this issue to life in new ways, which will be useful in advancing policy and practice conversations. Historically, conversations around credit loss often involved finger pointing and placing blame on high schools, community colleges, and receiving institutions. However, this study shows that the entire system has more work to do to mitigate excess credit accumulation. We argue that this way of deconstructing credit loss can be applicable to other contexts and degree programs.

Finally, the data from this study were accessible because of an S-STEM grant; this grant also provided resources for engineering students before transfer in the form of scholarships, co-curricular activities, and intrusive advising. Additionally, many transfer resources existed between sending and receiving institutions, such as numerous course equivalencies, guaranteed admissions agreements, and general education waivers. Despite the financial support and articulation policies, these highly advised students still accumulated excess credits—the credit-loss values we show here are likely a conservative estimate of what happens for students more broadly. This credit loss costs students time, energy, and money in addition to the opportunity costs associated with extending time to degree when one could be working. If we genuinely want to improve the transfer process so that this pathway can better meet its potential to broaden access to bachelor's degrees, we need to address the number of excess credits transfer students earn.

Acknowledgments

Many thanks to Walter Lee, Sarah Rodriguez, Natasha Smith, and Bevlee Watford for their helpful comments and support on this study. Additionally, thank you to the S-STEM students—they informed every part of this study.

Declaration of Conflicting Interests

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

This paper is based on work supported by the National Science Foundation, Directorate for Education and Human Resources, Division of Undergraduate Education under Grant No. DUE 1644138. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Open Practices

The data and analysis files for this article can be found at https://www.openicpsr.org/openicpsr/project/208901/version/V1/view.

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