An examination of community college and technical college engineering transfer programs: A focus on state-wide community college transfer and financial aid policies across Georgia, Colorado, and California.

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A focus on state-wide community college and technical college engineering transfer programs across California, Colorado, and Georgia

Introduction

With college costs increasing faster than inflation over the last 20 years, some students face financial barriers to attending many post-secondary institutions. States provide several avenues for U.S. citizens to pursue post-secondary education. Within higher education systems, community and technical college engineering programs offer lower tuition, numerous geographic locations, and more open enrollment opportunities than universities, functioning as accessible pathways to engineering degree programs. Additionally, the transfer function in higher education provides the access for students to complete core courses at a sending institution (transfer-focused community and technical colleges) and bachelor's degrees at a receiving institution (universities or colleges that admit transfer students) (Taylor & Jain, 2017). Students who come from low-income and systemically marginalized communities are more likely to begin their higher education in community and technical colleges before transferring to baccalaureate institutions (Berhane et al., 2023; Foley et al., 2020; Ogilvie, 2014; Rodriguez & Berhane, 2024).

In 2021, 40% of college graduates and 43% of employed engineering bachelor's degree recipients in the U.S. had attended a community or technical college at some point in their studies (National Center for Science and Engineering Statistics, 2023). While community and technical colleges that enroll students from marginalized communities have lower transfer-out rates than their counterparts (Jain et al., 2011), the students who do transfer to engineering bachelor's programs complete degrees at similar rates as their non-transfer peers in university programs (Cosentino et al., 2014; Terenzini et al., 2014). Although many engineering students have successfully utilized the transfer process, community and technical college programs are not fully integrated into statewide transfer networks. In this paper, we examine how transfer policies impact student pathways in three different statewide engineering education ecosystems. More specifically, we analyze how education policies impact the transfer experience for engineering students.

In this study, we examine how transfer policies impact prospective engineering students across three different states – California, Colorado, and Georgia. Our research question is: ***"What are the characteristics of statewide transfer policies and practices that impact engineering student transfer and credit mobility?"*** We discuss the impact of education policies on community college and technical college systems. We also review how relevant studies of engineering ecosystems contribute to the opportunities and challenges encountered by transfer students. Finally, we qualitatively analyze publicly available plans of study for engineering students transferring between higher education systems to answer the research question posed, and to identify implications for transfer policies and financial aid practices across states and systems. This study contributes to engineering education research by extending the analysis of institutional transfer partnerships to statewide educational systems. The findings encourage the design of policies and transfer structures that meet the needs of systems and the career goals of students.

Background/Literature Review

Modes of institutional transfer

There are many ways in which students transfer course credits between institutions to earn a degree in engineering. These include:

- *vertical* transfer, or course credit transfer from a community or technical college to a university,
- *lateral* transfer, or course credit transfer from a university to a different university,
- *reverse* transfer, or course credit transfer from a university to a community or technical college,
- *dual credit* or *concurrent enrollment* transfer from a high school to a community or technical college

Vertical and lateral transfer can support a student's completion of a bachelor's degree, while reverse transfer and dual credit transfer can support completion of an associate degree or certificate program (Dunmire et al., 2011; Katsinas et al., 2019). Our study focuses on *vertical transfer* from community colleges to universities in California and Colorado, and both *lateral and vertical transfer* in Georgia. The ways in which states enact transfers can support or hinder students trying to articulate their earned credits toward an engineering degree.

Course equivalency

Increased access and obstacles can emerge when receiving institutions enact structures and policies to determine the equivalency of courses from sending institutions. Through course articulation agreements, memoranda of understanding, or systemwide common course numbering, transfer partnerships work to align credit-hours, course topics, and prerequisite knowledge of their program coursework. A fundamental assumption of these partnerships is that equivalent coursework between receiving and sending institutions promotes successful student transfer and upper-division preparation. However, alignment is often determined solely by the receiving institution staff member, and does not consider differences in the mission, institutional context and student population of sending institutions. In other words, transfer admission may result in the matriculation of "similar" students, as opposed to students that are appropriately prepared for an engineering degree program. Although not explicitly a component of coursework equivalency criteria, discipline-based discourse around concepts of "rigor" plays a significant role in the alignment of engineering transfer partnerships (Montague, 2012). While community college and technical college programs are often acknowledged for their supportive learning environments (Berhane et al., 2023), they are simultaneously represented as providing less instruction than university equivalents (Grote et al., 2024). Rigor, within engineering degree programs, is typically associated with higher levels of math instruction, a competitive learning environment, and the social reproduction of a dominant, exclusive group (Riley, 2017). Rigor is also commonly associated with the Carnegie Classification of Institutions of Higher Education (CCIHE) R1 and R2 designations for doctoral universities, as determined by research expenses. Even though community and technical colleges are lauded as teaching institutions, their pedagogical practices, the lack of research expenditures, and the inclusion of students (and professors) from systemically marginalized communities are often incompatible with the ideas of engineering rigor; and thus restricts course equivalence between institutions (Montague, 2012). Given that university faculty commonly evaluate sending-institution coursework without

sending-institution representatives or regulatory oversight, coursework equivalency decisions made by receiving institution faculty may reflect program-specific concepts of rigor (A. Richardson, 2021; Senie, 2016). When sending-institution coursework is assessed as inequivalent, the transfer function of higher education contributes to the perception of a fractured engineering education ecosystem. The assessment of coursework equivalency is particularly central to transfer admissions, when compared to undergraduate and graduate admissions. In combination with other aspects of transfer admissions, the process of determining course equivalency contributes to student experiences of increased time-to-degree and credit loss.

Credit loss

Credit loss occurs when a transfer student's college coursework is not accepted by their degree program at their receiving institution. Credit loss varies across sending institutions, receiving institutions, and disciplines (Richardson, 2023), but may be lessened with strong articulation agreements. Articulation agreements are policies enacted between two or more institutions which define the process for transferring coursework. These agreements may also provide a suggested course plan to complete a bachelor's degree with transfer coursework. States which have a comprehensive articulation agreement in place are more likely to have transfer students graduate with a bachelor's degree even if there is no actual increase in the number of transfer students (Stern, 2016). This suggests that articulation agreements help keep students on track to graduation by minimizing credit loss. However, these agreements are frequently so confusing that students (Reeping & Knight, 2021; Z. W. Taylor, 2019) and even program advisors (Giberson, 2020) may not fully understand them. Administrators find that even with an articulation agreement in place, students may not know what courses will transfer until a degree-specific transfer evaluation after being admitted to the university (Ott & Cooper, 2014). Nevertheless, articulation agreements remain a cornerstone in transfer policy and serve as the baseline for evaluations of course equivalency and credit loss.

Engineering versus engineering technology

The discipline of engineering focuses on design and analysis, while engineering technology (ET), emphasizes the equally valuable skills of engineering applications and systems implementation (Committee on Engineering Technology Education in the United States & National Academy of Engineering, 2017). For example, an engineer may design a circuit breaker, but an engineering technologist or technician would assemble and repair the circuit breaker in the field. ABET accredits engineering and engineering technology as "separate but closely related professional areas that differ" in curricular focus and career paths. For this reason, ABET utilizes two different accreditation commissions: Engineering Accreditation Commission for engineering programs and Engineering Technology Accreditation Commission for engineering technology programs (*What Programs Does ABET Accredit?*, 2025). The formal separation between these two closely-related fields, and the prevalence of ET programs at sending institutions, have specific impacts on transfer students.

One of the key steps to becoming a professional engineer (P.E.) is attending an institution accredited by the ABET Engineering Accreditation Commission (National Council of Examiners for Engineering and Surveying, 2024). Yet, the Engineering Accreditation Commission only accredits engineering programs at the bachelor and master levels, making no recommendations for certificate programs, associate degree programs or transfer coursework (ABET,

2021). Because many community and technical colleges offer associate degrees (typically an unaccredited, two-year degree) in engineering science or engineering technology, students who aim to become a P.E. must eventually transfer and finish their degree at a baccalaureate-granting institution. However, university engineering programs do not consistently accept transfer applicants from these programs. When engineering transfer applicants are admitted, some of their previous coursework may not count toward their B.S. degrees. In comparison to lower-division engineering coursework in application-specific bachelor degree programs (e.g. Aerospace Engineering), transfer students complete less discipline-specific courses and more general education courses. The breadth of transfer student preparation, and the design of community and technical college programs may complicate assessments of equivalency with university coursework. As a result, engineering technology transfer students who are admitted into bachelor's degree programs negotiate unclear institutional enrollment policies, and transfer into degree programs with poorly designed course schedules (Grote et al., 2020).

Impact of financial aid on engineering transfer

While community colleges have lower average tuition than four-year institutions, students at community colleges still face high costs of attendance and inequitable distribution of financial aid. As example, in 2000, the California legislature passed Senate Bill (SB) 1644, which marked a shift in Cal Grant Programs, the state's scholarship program, towards entitlement grants. Through this program, California sought to meet two main objectives: increase access to higher education and lower student loan debt. These grants are meant to support students with financial need to pursue a higher education degree in a California college. Once awarded, these grants do not need to be paid back. Since the bill's passing, Cal Grants have predominantly been awarded to students with Grade Point Averages (GPAs) between 2.0 and 2.99 compared to students with GPAs between 3.0 and 4.0 (628,672 awards and 204,537 awards, respectively) (Quinto & Hauser, 2014). Because of SB 1644, there has been an overall increase in bachelor's degree attainment by 3 to 4.6 percentage points (Bettinger et al., 2019). What has seemingly not been addressed by SB 1644, however, is the distribution of population who have claimed these awards. California Community College (CCC) students in particular are among the most socio-economically disadvantaged in the state and make up over two-thirds of California's higher education student population, yet only receive six percent of resources awarded through the Cal Grant Program (Navarette et al., 2017). CCCs also disproportionately enroll higher numbers of African American/Black and Latinx/Latine students; consequently, Cal Grants are inequitably distributed to these groups compared to White and Asian American students (Reddy, 2021).

Even with all of the available grant aid considered, low-income CCC students are paying on average $5,000 per year to attend school (Cook et al., 2019). Recent studies have shown that lower-tuition colleges in California may have even higher net prices when factoring in all available aid and cost of living expenses. While the cost of attending a UC may be more than fifty percent greater than the cost of a CCC, UC students receive over three hundred percent more in grant aid (Szabo-Kubitz & Fung, 2020). Many community college students must balance employment with their studies, and may take longer to complete their degrees due to these financial constraints and structural barriers. This is compounded for engineering transfer

students, who complete more course credits than non-engineering students, and also face more difficulty in navigating the transfer pathway.

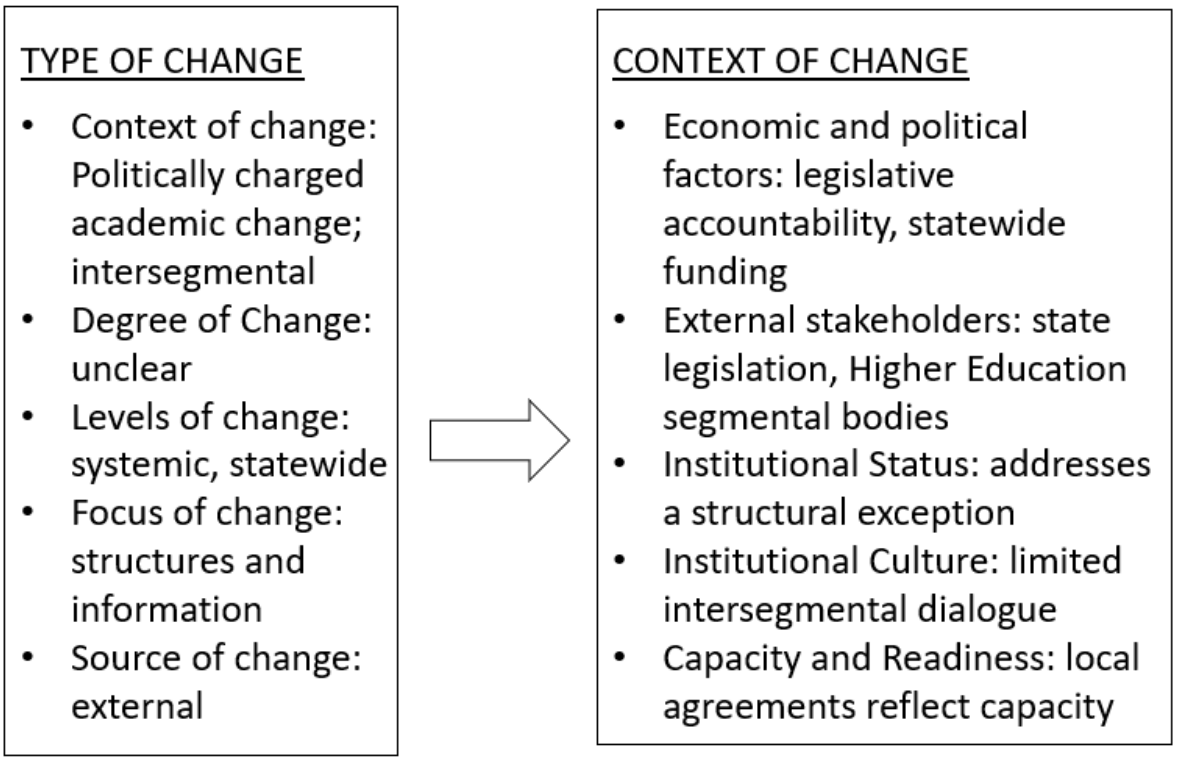
Literature Review Summary

From the engineering education literature, there are ample opportunities for additional research into the role of educational policy and statewide structures on engineering transfer networks. We know that education policies vary with modes of transfer in ways that impact the participation of community and technical college students. The practice of determining course equivalency in engineering pathways complicates an assessment of a community and technical college student's readiness for upper-division coursework. Educational policies and statewide structures may contribute to credit loss for engineering transfer students and the experience of partner institutions as separate, not seamless. Additionally, there has been little research done that 1) clarifies the treatment of engineering and engineering technology between higher education systems, and 2) disaggregates transfer practices based on the sending institution's program design. Finally, there is a need for research that explores how statewide financial aid structures influence the participation of engineering community and technical college students. Findings from this study will address these gaps in the literature and support the efforts of practitioners to improve engineering transfer networks.

Conceptual Framework

In order to analyze the research question posed, we draw from educational change theory to describe the type of changes that transfer policies may affect, and the context of the change within transfer networks. Transfer policies at the statewide and systemwide level may mandate changes to curriculum, funding priorities, resource allocation, program accreditation and admissions practices. At the heart of such change, new processes for communication between educators and system leaders, and with students would need to emerge. Transfer policies may require the redesign of organizational structures, articulation agreements, and coordination mechanisms. Such change necessitates commitments from policymakers, higher education administrators, and discipline faculty. Such changes would also involve employers, regional and national economic priorities, and engineering transfer student geographic mobility. Specific to engineering education, a cultural change in our institutional identities may need to occur before we can establish a capacity to network across systems. The characteristics of the change are represented in Figure 1.

Figure 1
Characteristics of the changes transfer policies create



Data and Analysis

In this study, we examined education policies and system-level structures in three states. We address the research question "What are the characteristics of statewide transfer policies and practices that impact engineering student transfer and credit mobility?" We compared the impact of statewide legislation and institutional agreements on course articulation and publicly available plans of students for engineering transfer students, with a focus on general education courses, engineering courses, and major-specific transfer requirements. The selected programs or policies are identified in Table 1. We also compared how systemwide structures encourage or deter community and technical college engineering transfer students.

Table 1
Selected statewide programs or policies in California, Colorado, and Georgia

State	Policy or Program Title	Brief description
California	Assembly Bills 928 (2021) and 2057 (2024)	Establishes a permanent Associate Degree for Transfer Intersegmental Implementation Committee to coordinate transfer pathways between California's public higher education systems with a focus on streamlining transfer.
Colorado	Associate of Engineering Science (2021)	Transfer partnership between Colorado's Community College system and participating university engineering degree programs designed to support transfer readiness and career preparation.
Georgia	Regents' Engineering Pathways Program (2016)	Cooperative program between the University System of Georgia and participating university engineering degree programs to expand access to the study of engineering.

California's Framework for Associate Degree Engineering Pathways

The California Community College (CCC) system has 116 colleges and is the largest higher education system in the nation. In combination with the California State University (Cal State) system and the University of California (UC) system, California is also home to the largest network of higher education transfer partners. In 2022, 2,459 engineering transfer students enrolled in programs in the Cal State system (*Workbook: Student Origins*, 2023), and 1,112 engineering transfers students enrolled in UC programs (*Transfers by Major*, 2023) from the CCC system. Of bachelor's degree graduates in the UC and Cal State systems, 29% and 51% of students started at a CCC, respectively (*Key Facts*, 2022).

Although there are institution-specific transfer programs (e.g. the UC Transfer Admission Guarantee and Cal State Transfer Success Pathway program), there are no statewide common engineering transfer courses, major specific requirements, or associate degree pathways for engineering transfer students who apply to public university engineering programs in California. While statewide model curricula and approved courses exist for engineering transfer pathways in California's Course Identification System (C-ID), "autonomous university engineering faculty have made independent changes to their lower-division curricula" to such a degree that no "single engineering course" is required by a similar bachelor's degree programs across the state (Dunmire et al., 2011, pg. 2). In other words, CCC students who want to apply to different engineering programs at a specific institution, or a single engineering major at different UCs and Cal States, will likely need to complete separate prerequisites for each program—with the understanding that all of their coursework will not be accepted by each receiving institution program—even though their transfer coursework is approved by the state for transfer. Hence, most engineering coursework is locally articulated between partner (often neighboring) institutions and petitioned by individual students. A lack of credit mobility is complicated by the fact that California's primary financial aid program (Cal Grant) has been less successful in supporting community college transfer student degree completion than non-transfer

students. While California community college students make up two-thirds of California college students, only about six percent receive Cal Grant aid (Navarette et al., 2017).

The development of new and the revision of existing Associate Degree for Transfer (ADT) pathways has been the primary focus of efforts to improve California transfer student success. In 2021, Assembly Bill (AB) 928 was approved by the governor of California to foster improvements in the academic achievement of transfer students (Student Transfer Achievement Reform Act of 2021: Associate Degree for Transfer Intersegmental Implementation Committee, 2021). In this context, a segment refers to one of the state's three higher education systems. The bill recognizes that opportunity gaps are the largest for Latinx/Latine and Black transfer students; and that a majority of transfer students experience transfer as unclear, complex, and incongruent with their educational plan (Hotchkiss, 2019). The bill also established The Associate Degree for Transfer Intersegmental Implementation Committee to 1) reduce credit loss before vertical transfer, 2) eliminate repetition of courses after vertical transfer, and 3) increase the vertical transfer of CCC students through ADT pathways. To earn an ADT, students must complete 18 semester units of major specific coursework and a general education course pattern (aligned with the Cal State or UC systems). With regards to STEM transfer students, the bill specifically adds that intersegmental transfer should be streamlined by degree pathway proposals with a "higher unit threshold." The December 2023 Final report from The Associate Degree for Transfer Intersegmental Implementation Committee specifically recommends increasing the maximum ADT unit cap by 6 credit-hours, and including an allowance for "general educational flexibility" in STEM ADT pathways (Fishbeck, 2023, pg. 8). Presumably, the higher unit threshold and course requisite flexibility would reduce credit loss, improve transfer preparation, and support the development of new ADT pathways with a large number of major specific course units for STEM bachelor's degree completers.

However, since the bill was approved, there remains numerous fields of STEM study for which no associate degree pathway in California has been adopted – including all engineering and engineering technology disciplines. While there have been recent efforts to develop an Electrical Engineering ADT, the AB 928 framework has not led to a proposal that has received intersegmental approval. While "science curricula often require a systematic progression of increasingly difficult courses", engineering disciplines interweave concepts from these course sequences with "the skills necessary to complete a field experience, internship, or capstone course … making it challenging to design timely and seamless pathways in vertical transfer" (Grote et al., 2021, p. 4). Additionally, engineering degree programs in California's three higher education systems are differently equipped to approach their engineering program design in terms of faculty, facilities, and funding. This is evidenced by the diverse integration of courses (e.g. laboratory courses, design courses and professional practice courses) alongside applied science, the treatment of pre-requisites or co-requisites to theoretical engineering coursework, and the variation in the design of engineering degrees. It is also reflected in the institutional workplace conditions, industry partnerships, and resources available for engineering faculty in each system. The issue is not just about credit hours and GE courses. It is about the design of engineering discipline associate degrees that meet the needs of all system partners, including each higher education segment's public mission and the communities they serve. Any such proposals would necessitate support from faculty and shared governance bodies in the CCC, the

Cal State, and the UC system, in addition to the California legislature. The ADT model calls for a level of systemwide dialogue, political support, statewide funding, and curricular reciprocity that is not currently present in California's engineering programs. In other words, the support for an improved California engineering transfer ecosystem may not lie in the approval of any pending proposal. It may be found in the work of system change agents and network partners that can adopt the degree of change needed to reduce credit loss, eliminate course repetition, and enhance vertical transfer in local determined engineering pathways. The incomplete work of The Associate Degree for Transfer Intersegmental Implementation Committee will be extended beyond the July 1, 2025 deadline by a new California assembly bill (AB 2057) that makes the committee permanent. Perhaps, this legislative impetus will provide the momentum needed for the consideration of new change agents and system partners in California.

Colorado's Associate of Engineering Science Degree

The Colorado Community College System (CCCS) is made up of 13 two-year institutions located throughout the state. Tuition is assessed per credit hour. For in-state students, tuition is $285.10 per credit in an on-campus course and $393.80 per credit for an online course as of Fall 2024. The College Opportunity Fund grants in-state students $116 per credit hour, up to 145 total undergraduate credits (Colorado Community College System, 2024a). While Colorado's statewide vertical articulation policy is generally strong, it has not historically supported engineering transfer partnerships. All community college courses in Colorado have common course numbering, and there are many Guaranteed Transfer (GT) general education courses that are accepted at any state institution. Engineering courses are not usually GT due to a lack of equivalency in the learning outcomes of different four-year institutions, and even among different departments within the same institution. Colorado also has a system of Degrees with Designation (DwDs) which include 60-credit Associate of Arts (AA) or Associate of Science (AS) degrees. For first-time students at a CCCS colleges, the Bridge to Bachelor's Degree program allows them admission with junior status into one of thirteen participating universities upon completion of a DwD (Colorado Community College System, 2020). However, there is no DwD for engineering, as the first two years of an engineering program require more math, science, and technical electives than an AA or AS support.

There are three major transfer receiving institutions in Colorado – the University of Colorado (CU) (including locations at Boulder, Denver, Colorado Springs and flagship locations in rural areas), Colorado State University (CSU) (including locations in Fort Collins and Pueblo), and the Colorado School of Mines (in Golden). Each of these institutions enrolls transfer students from the CCCS in a variety of engineering disciplines. Each institution accepts GT coursework, including the math, science, and non-STEM electives needed for an engineering degree. In addition, recently-introduced associate degrees with a focus on engineering have resulted in introductory engineering coursework transferring from CCCS colleges.

The Associate of Engineering Science (AES) degree was approved in Colorado by the Higher Learning Commission, a college and university degree accreditation board, in 2021; and this degree was offered as a pathway to students beginning in 2022 (Whaley, 2021). Currently, there are AES degrees in Mechanical, Civil, General, Electrical, Computer, and Architectural Engineering. The AES degree provides a mechanism for Colorado students to complete a two-

year degree in engineering without taking excess general education credits, and for new articulation agreements to be formed between individual CCCS colleges and four-year engineering schools. This is a much clearer pathway for Coloradoan engineering transfer students than existed previously. Before the AES was implemented, full-time students would take GT math, science, and humanities courses at the community college, or possibly earn an AS with credits that did not necessarily articulate to a four-year engineering degree. Many students still spent 4 years at the university after transferring. The AES and subsequent articulation agreements allow engineering students a full-time pathway to an engineering degree within 4-5 years, and do not require students to repeat courses or take courses which do not apply to the engineering bachelor's degree. The articulation agreements differ by university, but generally a student's AES degree will leave them with 65-70 credits (about 2 years) of coursework to complete at the baccalaureate-granting institution.

There are still many reasons students may be delayed in their coursework or lose credits, compared to non-transfer students, but for perhaps the first time a Colorado community college student can complete a four-year engineering degree in four years. However, enactment of this policy can be fragmented and confusing. Different institutions advertise the AES differently to their students, as do different departments in those same institutions. These agreements are in a constant state of amendment as competencies are updated and programs change. Colorado State University, for example, is currently creating a common first-year for all engineering majors, which eases transferability of coursework from the community college as there are fewer discipline-specific considerations. However, existing websites do not always reflect the most up-to-date information. For ease of comparison, Table 2 provides an overview of three articulation agreements (Colorado Community College System, 2024b). These articulation agreements are written for Mechanical Engineering and General Engineering, and they assume that a student is ready to take Calculus I when they declare the AES. This analysis is based on publicly available information from the institutions' websites – so may not be the most current.

Table 2

A comparison of the AES degree transfer pathways in Colorado

	Colorado State University (CSU) – Mechanical Engineering	University of Colorado (CU) – Mechanical Engineering	Colorado School of Mines (Mines) – General Engineering
Required Units for BS degree	129 credit-hours	128 credit-hours	Not specified
Time-to-Degree for transfer students	4 years full-time	4 years full-time	Minimum of 5 years
Documentation from public-facing institutional websites	Detailed 2+2 transfer guide including an AES	Example pathway indicates 5-years, 136 units and no AES degree	2+3 transfer guide with specific guidelines for coursework to take at the community college

While the AES degree provides a clear framework, the application and student experience vary for receiving institutions and disciplines/ departments. Certain departments accept nearly all CCCS engineering courses, while others will accept only a select few. Additionally, Colorado School of Mines currently only has an articulation agreement based

around the General Engineering AES, and some CCCS engineering classes count as electives, rather than toward the engineering bachelor's degree. Similar issues exist across different departments at CU and CSU. This requires an engineering student to decide upon both their major and intended transfer destination before beginning coursework at the community college, or risk losing credits in the transfer process. Nevertheless, the AES represents a step forward in standardizing the process of engineering coursework and has resulted in greater participation in engineering at community colleges across the state.

Georgia's Regents Engineering Pathway Program

Georgia's 22 public two-year institutions reside in its Technical College System of Georgia (TCSG). TCSG colleges award degrees up to an associate's level, and they are committed to "a quality, affordable education with flexibility to earn a degree while you are still employed" (Technical College System of Georgia, 2024). As of Fall 2024, all TCSG colleges charge a standard, in-state tuition based on credit hours. TCSG colleges charges in-state students $107 per credit hour with a maximum tuition of $1,605. Semester fees vary between $400-$600 per institution and are paid by the student regardless of the number of credit hours matriculated. Hence, an in-state TCSG student taking 15 or more credit hours would pay up to $4,410 per academic year in tuition and fees. However, Georgia provides low cost or free tuition at TCSG institutions through initiatives, such as dual enrollment and the HOPE Grant. The former allows students to earn up to 30 hours of college credit for free while still in high school, and the latter provides up to 63 credit hours of financial support for Georgia state residents.

Georgia's 26 public, four-year institutions are housed in its University System of Georgia (USG). Each of USG's bachelor-level, engineering degree granting institutions are ABET-accredited. However, each institution's degree requirements may vary for the same degree, provided they meet the general requirements of the USG. Tuition costs vary depending on the USG institution. As of Fall 2024, larger institutions, such as the University of Georgia (UGA) charge in-state students $11,440 for yearly tuition and mandatory fees. Smaller institutions, such as Georgia Southern University, charge in-state students $7,144. Georgia provides the HOPE Scholarship for Georgia students who attend USG schools. The HOPE Scholarship is merit-based, and pays for a certain amount of tuition, depending on a student's GPA and SAT score.

Georgia permits USG students to transfer into select engineering bachelor's programs via its Regents Engineering Pathway (REP). REP allows students from one of Georgia's USG four-year institutions to transfer to one of its four public universities, which offer a BS in Engineering degree: Georgia Institute of Technology (Georgia Tech), University of Georgia (UGA), Georgia Southern University, or Kennesaw State University (KSU). Students on the REP pathway transfer nearly all of their 30 or more hours towards their engineering degree. However, REP does not formally allow for students from Georgia's stand alone, two-year colleges to participate.

The policy has enabled thousands of students, including many engineering students, to move between USG institutions. According to USG's Undergraduate Student Transfer Report 2022-23, 10,744 students across all disciplines transferred between USG colleges and 6,608 students transferred from in-state non-USG Institutions to USG Institutions. TCSG accounted for 4,159 transfers into USG institutions. However, TCSG students are not able to benefit from the REP (University System of Georgia, n.d., pp. 2-4).

TCSG has articulation agreements for engineering technology majors to transfer to universities. While USG offers engineering degrees, TCSG only offers associate degrees in engineering technology (ET). Classes within TCSG's engineering technology programs are not

considered equivalent to USG's engineering curricula. And similar to California, there is no statewide approved associate degree for any engineering discipline. As a result, if engineering technology students transfer to a university engineering program, they will only transfer a maximum of 18 hours of applicable credit toward an engineering degree. Because engineering disciplines determine which engineering technology coursework is accepted at the receiving institution, engineering disciplines have an important role in the development and formation of transfer partnerships.

There is a precedent of an associate degree pathway in the REP. Georgia State University (USG) merged with Perimeter College in 2016. Currently, Perimeter College sits as one of Georgia State's 12 colleges and contains pathways which utilize REP with student enrolled in associate degree programs. Although Perimeter College is not a TCSG institution, the TCSG could use Perimeter College as a template to implement an engineering associate degree pathway for its colleges. Because all TCSG institutions implement the same curricula, an engineering associate degree pathway can be created, approved, and implemented at the system level. This approach has the potential to vastly transform the engineering transfer ecosystem in the state of Georgia.

Results

We sought to answer the question, "What are the characteristics of statewide transfer policies and practices that impact engineering student transfer and credit mobility?" In doing so, we recognize that our analysis is subject to several limitations. Our study examined specific policies and structures that impact engineering transfer students in three states, and our approach may limit the generalizability of the findings. Transfer partnerships and educational policies are designed for specific student populations whose needs may differ across states. Future research can address these limitations by including data from other states, and disaggregating the impacts of policies on different student populations and across different engineering disciplines (e.g. engineering technology). Despite these limitations, we discovered similarities between the engineering transfer policies in Georgia, Colorado, and California. Foremost, each state has a system of guaranteed articulation for general education coursework. Second, there is some form of support for engineering transfer partnerships in each of the states. Finally, each state has bilateral partnership agreements between transfer-sending and transfer-receiving institutions, which facilitate the transfer of engineering coursework.

Beyond these similarities, each state has student populations and institutions with unique needs. Colorado has the smallest of the three higher education systems, with significant concern for rural student access. This drives the implementation of common engineering transfer courses to boost overall enrollment. California has the largest population of students and a large volume of receiving programs, leading to specialization and variation in requisite coursework among transfer-receiving institutions, and less acceptance of engineering transfer courses unilaterally. Georgia's technical college focus on engineering technology programs makes statewide transfer programs difficult, but historical relations between transfer-sending and receiving institutions have nevertheless led to bilateral transfer agreements. Refer to Table 3 for a summary of the transfer potential for GE and engineering coursework in each state.

Table 3
State and systemwide structures that impact engineering transfer.

State (and system partner)	Common General Education (GE) course	Common Engineering Transfer Courses	Common Major Specific Transfer Requirements
Technical College System of Georgia	Yes, and GE course requirements and exemptions vary by receiving institution and discipline.	No. Different engineering and engineering technology majors apply different limits to transfer credit.	No. Each program's degree requirements may vary for transfer students from different schools.
Colorado Community College System	Yes, and GE course requirements and exemptions vary by receiving institution and discipline.	Yes, but course equivalency and program requirements vary by institution and program. Many course articulations require bilateral agreements.	Yes, but each program's specific requirements may vary for transfer students from different sending institutions.
California Community College	Yes, and GE course requirements and exemptions vary by receiving institution and discipline.	Yes, but course equivalency and program requirements vary by institution and program. Many course articulations require bilateral agreements.	No. Only local bilateral agreements provide recognition for pre-transfer certificates and associate degrees in engineering. There is no statewide recognition of engineering ADTs.

Note: Policies highlighted in green support transfer student success. Policies highlighted in yellow offer mixed results for transfer students. Policies highlighted in red do not positively impact transfer student success.

When comparing the impact that these policies have on transfer students, the challenges to transfer networks become clear. Georgia's lateral transfer program allows students enrolled in university programs who may not have started in an engineering bachelor's program to transfer and finish an engineering degree. However, restrictive policies on transfer credit and the inequivalent treatment of engineering technology coursework mean that community and technical college transfer students may still lose credit. Colorado is the only state, of the three, with an associate degree specifically in engineering, establishing a two-year transfer program without excess GE credits. Nevertheless, these degrees are nascent and subject to changes as transfer receiving institutions modify curriculum. They also require students to navigate complex transfer plans that depend on both major discipline and receiving institution. This can lead to credit loss if a student is not settled on their discipline, or if the transfer requirements change. California's state government has structural support for transfer students generally, resulting in increasing numbers of transfer students and bilateral transfer agreements. However, this support has not led to a consistent statewide transfer program in engineering, so students

must navigate institution- and department-specific policies; and are not guaranteed to receive credit for engineering coursework taken at the community college. The benefits and shortcomings of the statewide policies are summarized in Table 4.

Table 4
Policy exceptions and conditions for engineering transfer students

State	Statewide Transfer Pathways limitations	Conditional University Transfer Partners	Localized Course Articulation
Georgia	The Regents Engineering Pathway (REP) is limited to lateral university transfer	Georgia Institute of Technology, University of Georgia, Georgia Southern University, and Kennesaw State University are consistent transfer-receiving institutions.	USG lateral transfer students can transfer 30 units into engineering technology programs, but vertical transfer students from TCSG can only transfer18 units into engineering programs at partner institutions
Colorado	The Associate of Engineering Science (AES) is for select engineering disciplines at state institutions.	The AES degree is currently only accepted at Colorado State University, University of Colorado, and the Colorado School of Mines.	Engineering transfer coursework is suspect to credit evaluation, varies based on sending and receiving institution, and necessitates a rigid course schedule.
California	The are no statewide engineering pathways. Transfer students can participate in transfer admission guarantees and dual enrollment, and bridge programs.	Engineering programs in the California State University and University of California vary in their transfer pathway partnership.	Despite statewide policy and the development of intersegmental transfer model curricula, course articulations vary by program and institution-specific agreements.

Note: Policies highlighted in green support transfer student success. Policies highlighted in yellow offer mixed results for transfer students. Policies highlighted in red do not positively impact transfer student success.

Conclusions

Cumulative Impacts on students

While any statewide action toward creating engineering transfer programs could be a boon for access to engineering degrees, there are several areas of negative impact for students. The main concern in any transfer agreement is credit loss, as it represents lost time and money for the individual student and poor partnership between systems. Credit loss occurs when limits

on transfer credit are placed unnecessarily, as in the case of the Georgia system. It can also stem from inconsistent or outdated information. Students are often forced to navigate outdated or conflicting information from transfer institution websites, which can lead to uninformed decisions through no fault of their own. As engineering departments at transfer-receiving institutions constantly work to improve their own curriculum, they risk the denial of transfer student credits without close involvement of transfer-sending institutions in these decisions. Additionally, this may create needs for additional resources at the transfer-receiving institution to address curricular misalignment. This results in longer time to degree for these students, or potentially lower rates of bachelor's degree attainment. Finally, receiving institutions and departments within them have different policies for accepting engineering coursework. This leads to credit loss if a student is following one pathway (like the Mechanical Engineering AES in Colorado), but transfers to a department which does not accept some of the engineering coursework. In both California and Colorado, students are faced with tight and hard-to-navigate transfer pathways which require them to make decisions about their intended major and transfer destination well in advance of transfer. This can lead to credit loss as students change their engineering discipline or take coursework that satisfies an associate requirement but not a bachelor's requirement. In recognition of this challenge, states can play a larger role in addressing the misalignment between the course requirements of transfer partners.

Considerations for education policy and novel transfer structures

In response to the experiences of students and the design of transfer structures, policy makers should consider how to reduce the negative impacts on transfer students and transfer networks. Each of the statewide policies presented has benefits that may be considered in future models, as well as challenges that should be addressed. In Georgia, a strong lateral policy and agreements between universities make transfer seamless, but the lack of engineering coursework at the technical college limits effectiveness. With a shared commitment to honor the prior knowledge of technical college students, sending and receiving institutions can collaborate on an adaptation of the Regents Engineering Pathway for vertical transfer students. In Colorado, the associate degree in engineering limits credit loss by taking discipline-specific courses early on, but requires students to know their intended degree and transfer destination very early to avoid credit loss. While this pathway is poised to expand access to transfer students, it is unclear how well these agreements support student's timely completion of associate and bachelor's degree requirements. In California, legislation that aims to reduce credit loss and improve financial aid is met with little consistency across and incomplete implementation across transfer-receiving engineering institutions. Given the diversity and volume of engineering programs and institutional partnerships, California is due for a bottom-up transformation led by research-practitioners; instead of a top-down, compliance-oriented approach (Dunmire et al., 2011).

Recommendations for transfer partnership practices

Based upon this analysis, we believe that the state of engineering transfer across the U.S. is highly fragmented and reliant upon bilateral institutional agreements. While current agreements offer a place to plan for the future, it does not reflect a systemic approach that cultivates excellence across partnerships or through reciprocal consideration of each partner's

contributions (in the way that graduate education is engaged by partner networks). We recommend future transfer partnerships adopt the following practices to reduce credit loss, revise network structures, and re-envision the transfer function in higher education:

- Transfer-receiving institutions and transfer-sending institutions should engage in collaborative conversations about curriculum changes and transfer preparation beyond course articulation and credit mobility.
- Statewide and systemwide authorities should collaboratively create two-year degree plans in engineering, which explicitly reduce the GE coursework needed to obtain such a degree, limit credit loss for engineering transfer students, and replace a network of bilateral agreements with a common partnership.
- Both transfer-sending and transfer-receiving institutions must provide consistent information on articulated coursework. Accordingly, websites and advisors should be updated whenever a change is enacted.
- Transfer policy should be driven by the state to improve course consistency within and across higher education systems, with integrated support from both transfer-sending and receiving institutions, guided by research and collaboration.

Policy and transfer structures should be informed by longitudinal student data and designed for the success of post-traditional students (Laanan & Jain, 2016; Wyner et al., 2016). The above recommendations require expertise, time, and dedicated effort. States should consider how to equitably include the perspective of discipline-specific cohorts at both sending and receiving institutions in the work of administrating and communicating engineering transfer networks, while also engaging change agents at the system level. Transfer has historically been important across U.S. higher education, and it is becoming increasingly important for engineering professionals. Future transfer policies will have enormous impacts on the nation's workforce and thus, require careful consideration. The benefits and challenges outlined in this paper will hopefully serve to inform future conversations about engineering transfer student ecosystems.

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