How We Did It: Building a Two-Year Transfer Path One Practice at a Time

Dr. Heidi G. Loshbaugh, University of Colorado Boulder

Heidi G. Loshbaugh, Ph.D., is passionate about higher education's role in the public good. She has taught, conducted research, and served as a college administrator with a keen focus on equity. As a community college dean, she was PI for a $3.5M US Dept. of Ed. award to transform STEM education. Her implementation of math corequisite instruction led the B & M Gates Foundation to fund an ROI study that revealed the time and cost savings for students, the cost effectiveness for the college to implement the reform, and the dramatic improvement in completing college-level math for community-college students. She consults with states and institutions to improve student success in college, particularly with Complete College America (CCA). At University of Colorado Boulder, Heidi is a Senior Research Associate in Ethnography & Evaluation Research, a center focused on STEM education. She recently was the project lead in transforming teaching evaluation practices in the College of Arts & Sciences and supports the College of Engineering and Applied Sciences and the Graduate School with special projects. A fourth-generation Coloradoan and educator, she lives in Denver with her husband, two college-aged children, and rescue dog.

Chris Anderson, University of Colorado Boulder
Dr. Nick Stites, University of Colorado Boulder

Nick Stites is the Director of the Integrated Teaching and Learning Program at CU Boulder and an instructor with the Integrated Design Engineering program. Dr. Stites is the principal investigator (PI) of the Denver-Metro Engineering Consortium, which is a partnership between local community colleges and universities to support engineering pathways for transfer students. He is also involved with ASPIRE, an NSF Engineering Research Center that is focused on developing the technology and workforce for electrifying the nation's transportation system. Dr. Stites earned degrees in Mechanical Engineering (BS Colorado State University, MS Purdue University) and Engineering Education (PhD Purdue University). His research interests include the development of novel pedagogical methods to teach core engineering courses and leveraging technology to enhance learning experiences and broaden access to engineering education. He has experience as a practicing engineer and has taught at the university and community-college levels.

Ms. Janet Yowell, University of Colorado Boulder

Janet serves as the Director of Strategic Community College STEM Initiatives for the College of Engineering and Applied Science at the University of Colorado Boulder. In this capacity, she develops systems-level programming to positively affect two- to four-year transfer pathways in STEM (particularly engineering) for the college. She currently works with 30 community colleges nationwide (including in Colorado) to better prepare developmental math community college students for transfer into STEM bachelor's degree programs or entry into the STEM workforce.

How We Did It:
Building a Two-Year Transfer Path One Practice at a Time

Abstract

This paper discusses a systems-thinking approach to improving engineering-student transfer from community colleges into Colorado's flagship university. We approached transfer as an intricate web and established tools, practices, and relationships to guide students along the many strands. The work has been practical and applied; although we used education research to inform the adopted changes, *this paper is not a discussion of research findings.*

Colorado has high levels of technical employment but low levels of post-secondary degree completion among residents. The University of Colorado Boulder (UCB), the state's flagship, plays a key role in state workforce development, yet, for students starting in one of the state's community colleges, transfer leading to engineering graduation at UCB has been rare.

About a decade ago, one co-author left his community college job to begin recruiting and advising engineering students at UCB. He immediately noted low transfer rates and discovered unfavorable policies/requirements for community college students relative to students who began college at the university. He connected with stakeholders at UCB, at his former community college, and across the state. Thus began our team.

Through National Science Foundation support, we convened universities, two-year institutions, K-12 districts, and the state higher education department to identify problems and solutions. Annual convenings focused on academic advising, transfer credit/admissions, policy, curricular learning outcomes, course transferability and degree applicability, communication, data, and financial aid, among others. Concurrently, deans in the five metropolitan community colleges received NSF funding to dismantle transfer barriers within the two-year system and enhance transfer student success statewide.

Our team led UCB to identify and strategize how to articulate engineering-specific courses unavailable in the community colleges. These efforts, supported by collaborators across the state, eventually resulted in more efficient transfer pathways; two- to four-year transfer agreements; and an Associate-in-Engineering-Science degree—all of which have further facilitated transfer in engineering.

With recent external funding, we started paid summer-research internships in engineering so that two-year students can gain pre-professional experience early in their academic journey.

Our systems-thinking approach helped create structures and practices so that students can begin at community college and transfer seamlessly to any state public engineering program, and we are seeing success. Even as transfer numbers are stagnant or declining elsewhere across our campus, for fall 2024, our college enrolled the largest-ever cohort of in-state community college students and the second-largest overall transfer fall cohort. Since fall 2010, overall engineering transfer student enrollment has grown 152% (25% increase in the last 5 years). In-state community college matriculation has grown from less than 20 students in 2010, to over 75 in 2024.

We are proud to perform this work in support of our college mission, which includes generating new knowledge and supporting students to become leaders and citizens who improve our world and the people in it [1].

Introduction

This paper tells the story of systemic change. Over more than a decade, members of this multi-disciplinary team have collaborated across roles, projects, and institutions to address a long-standing problem: low success rates for students who begin in community college, transfer to universities, and complete degrees in engineering. Through evidence-informed practice, we have used qualitative and quantitative data, professional experience, and prior research to drive student-centered change.

We use qualitative [2] and quantitative data to examine how a group of practitioners substantively improved transfer outcomes from community colleges into engineering. Using rich details, we share a descriptive case study [3]-[7], largely but not exclusively focused on the College of Engineering and Applied Science at the University of Colorado Boulder (UCB). This data-informed **work** was reflective, iterative, change-oriented, and operational; it matters because it describes beneficial change in a stubborn problem—community college to university transfer and completion, which has persistently yielded poor outcomes across the U.S. In the spirit of Paolo Freire, we describe our praxis, about which Peter Mayo asserts, "Praxis is geared to transforming the world, that is to say, one intervenes in history to contribute towards its development" [8]. This paper is **not intended to contribute to theory**. Nevertheless, even without a research protocol, we followed activities that can be replicated, and that research has identified as beneficial [9]-[11]. We share our change **process** [12] with the hope that others can adapt it to their own contexts [2].

We frame this case study with the following questions:

- What primary actions did this team take to improve transfer practice in the state's higher-education institutions?
- Why was a *network* of higher education stakeholders central to successfully addressing transfer barriers?
- What steps did the collaborators take to implement the described changes? Why did a systems-thinking approach support their work?

Transfer in context

In the U.S., community-college-to-university transfer offers potential to increase engineering degree completion, particularly for students who lack college-educated community role models; who are experiencing low income and/or housing insecurity; and/or who need the support of smaller classrooms to develop academic confidence and skills [13],[14]. However, transfer's potential to improve bachelor's degree completion has not yielded success—despite 30-plus years of focus and investment [13]-[31].

Colorado hosts strong employment in technical fields, and by 2031, 69% of jobs in our state will require some sort of post-secondary education [32],[33]. In Colorado, 62.9% of residents held post-secondary credentials, making it among the most highly educated U.S. states [34]-[37]. "Economists estimate that the demand for college-educated adults in Colorado is the fifth highest

among all states [38] in the nation." However, in 2023, our state ranked 49th in the U.S. for higher education funding [32]. Thirty of 64 counties in our state are described as "educational deserts," and only 49.9% of high school graduates enter post-secondary education—compared to the national average of 61.8% [34],[35]. The state's economy is relatively resilient and growing, but its workforce is supplied by inward migration of talent from other states [32]. The state's 2017 higher education master plan sets targets including to increase credential completion, improve student success, and invest in affordability and innovation [38]. This context frames our work on improving transfer into our engineering college.

Of in-state students who matriculate, many begin in a community college. Only 14.1% of Colorado's community college students actually transfer to a university, even if they aspire to a four-year degree [39]. In our large, western state, rural students enroll in college at lower rates than the state's overall average [40]-[42]. Rural students are more likely to start in two-year colleges; earn credentials *lower* than bachelor's degrees; and, if they attend four-year colleges, they earn bachelor's degrees at lower rates [43],[44]. Students who are the first in their family to go to college often choose to study close to home [45] and family. This pattern occurs more frequently in families experiencing economic insecurity [44],[46], and local community colleges offer essential opportunities for post-secondary education. However, students who attend four-year institutions further from home are more likely to graduate with a bachelor's degree [47]. These and other data indicate students' interwoven barriers as they enter higher education and point to the complexities faced by Colorado citizens who pursue higher education [13]-[15].

UCB plays a key role in state workforce development, but degree completion, particularly in engineering, has been low. As with other U.S. states, Colorado is facing a decline in high school graduations [48], and thus enrollment. To address the education and business needs of our institution, students who transfer from community colleges comprise a key population. Supporting Colorado's students to complete degrees serves our campus' public mission and also makes good business sense. Improving transfer outcomes is also key to fulfilling Colorado's higher education master plan, which calls for increasing credential completions by 9,200 *beyond* natural enrollment growth and boosting completion of the STEM credentials urgently needed for our state's workforce.

At the turn of the 21st century, transfer leading to engineering graduation was rare for students starting in a community college [9]. Colorado was no exception. About a decade ago, one member of this team left his community college job for a career as an academic advisor for the engineering college at UCB. He immediately noted the low transfer enrollment, weak retention and graduation rates, and discovered inequitable admissions policies/requirements for community college transfer applicants relative to incoming first-year students. With the blessing of leaders in the engineering-dean's office, he connected with former two-year colleagues to problem solve. At that time, another team member was a community college STEM dean in an HSI and passionate about transfer as a means for students to study engineering in a cost-effective way. Meanwhile, a third team member became the project manager for a multi-year funded initiative to transform STEM transfer processes. We formed a statewide working group to address the challenges we found and now share key features of our work, including impact data.

Logical framing

While this discussion is **not** a report of research findings, social-science research methods informed our **practice**. Here we offer a logical frame for our case study and identify relevant methods that informed our work, including case-study research, action research, and grounded-theory research [49].

Case studies can refer both to the study method, strategy, focus, and result/or of investigation [50],[51]. We discuss our practices, processes, and impact/outcomes [52], with the intent that others could adopt aspects of our study to benefit their work. This **non-research, descriptive case study** [5, p. xxi], discusses how we approached our state's ecosystem of higher education [53],[54], in context [3], not to discover but to address [50] factors that influenced low transfer success among pre-engineering community college students.

To illustrate how our actions connect to qualitative-research design, we call on Kurt Lewin's work, as depicted in Figure 1 [57]. Action Research practices [55],[56] emerged from sociology and are commonly used in educational settings to address problems through *stakeholder participation*. Action Research [57] uses qualitative and quantitative data to contextualize problems, identify prior knowledge, and develop relevant solutions. We included stakeholders across the state, recognizing that their expertise with conditions in their contexts could lead to stronger outcomes. This work did not begin with a holistic research design; nevertheless, we conduct research and implement research-based practices regularly in our professional practice.

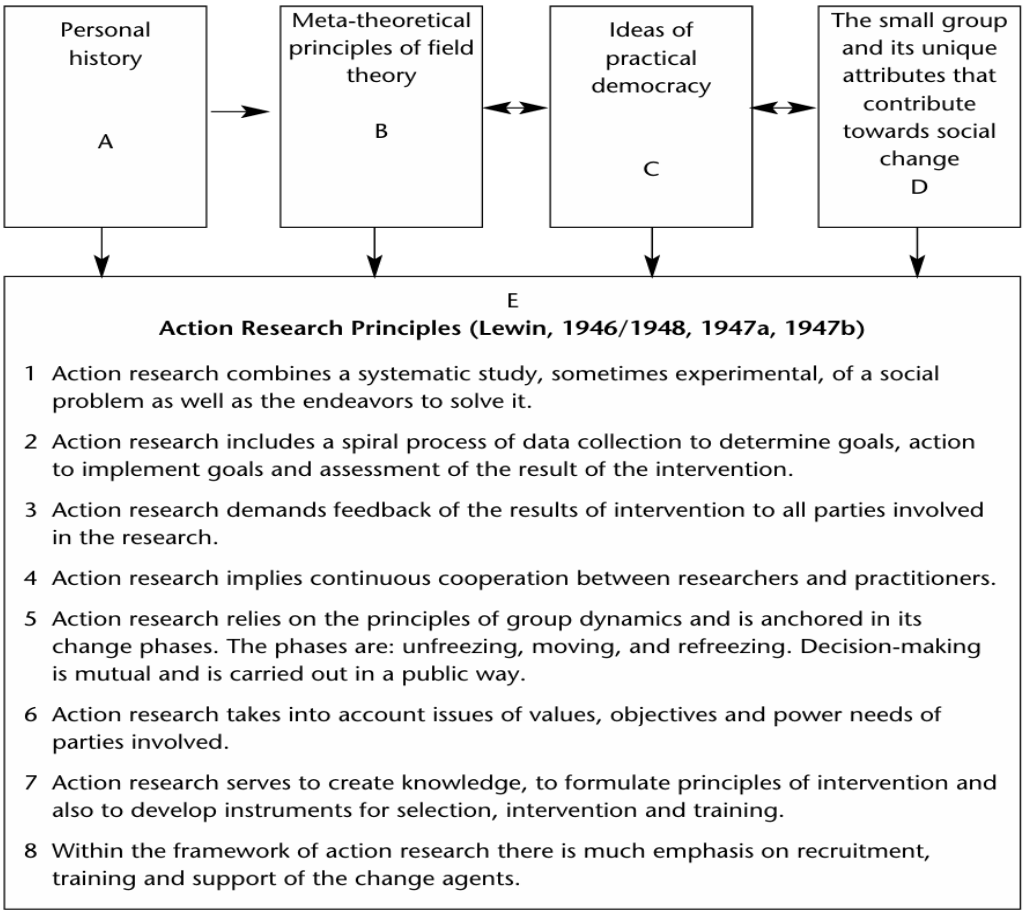

Figure 1. Personal and intellectual influences leading to Lewin's paradigm of action research [57].

Data sources

Qualitative data sources include meeting minutes, annual institutional reports, outcomes from stakeholder meetings, participant reflections, observations made during statewide convenings, and analysis of institutional and higher-education-system documents. Quantitative data sources include institutional and national data sets [58]. Education-research sources are cited as relevant to each topic under discussion. Policy artifacts come from public-facing state websites.

Our approach

For more than a decade, we have sought and embraced the expertise across our state to understand problems affecting transfer, identify the root causes, seek or create solutions to the problems, and refine as we learned more. We took a systems-thinking approach and honored the independence of each organization [59], including K-12, community college, university systems, and the state system of higher education, even as we worked to improve their interrelated operations *within* our state.

Although members of our team all now work at UCB, several of us have worked in other public institutions, which shaped our view of community-college-to-university transfer as an intersecting web [55] of practices, governed by policies, and informed by processes—some of which were conflicting or even confounding. As we uncovered the gaps, inconsistencies, and even oddities in our state's transfer processes, we could better guide students along transfer's many strands rather than assuming students could or should navigate the intricate web alone. We discuss activities that included external stakeholders across our state *and* the direct impact on our campus. We cannot represent the experiences or outcomes from other institutions. Our focus, therefore, is on the activities and impact of our work *on our campus*.

Central to this discussion are four key categories: policy, people, processes and practices, and products.

Policy

We discuss policy [60]-[62] not to analyze the policy itself [63] but rather to describe the *impact* of specific transfer policies at multiple levels: departmental, college, institutional, systems, and state. Our approach is applied, and we discuss policy relevance apropos this question:

> How did specific policies at distinct levels of the state higher-education ecosystem either support or hinder successful transfer outcomes?

LaViolet and Wyner define transfer [64, p. 5] and

> articulation agreements—in their most basic form— as formal arrangements between institutions at the individual, system, or state level that aim to facilitate credit transfer between two-year and four-year schools.

Within the function of transfer, multiple systems and policies intersect—not always to the benefit

of students. Sometimes, policies "owned" at each level can affect the success of transfer, and coordination between actors is notoriously poor [64]. To improve transfer efficacy, we realized that we had to affect not only any given policy but also the *intersections between* distinct policies at different levels [65].

Colorado is home to a system of thirteen state community colleges, two district colleges, and fourteen public four-year institutions. Governance authority is granted by statute. As do 19 other U.S. states [66], Colorado's public postsecondary education has a statewide coordinating board which oversees independent degree-granting institution authorization. Two-year institutions are governed by the State Board of Community Colleges and Occupational Education, with the exception of the two district colleges.

According to the 2019 Education Commission of the Sates Policy Guide, "Postsecondary education governance relates to the responsibilities and authority of entities and leadership positions charged with developing, implementing and overseeing policies and practices" [67]. Our state has strong higher education policy [67], yet the impact of those policies often is not commensurate with their intent. For example, enacted policies would seem to offer seamless migration from two-year to four-year campuses. Examples include a common-course numbering system [68] across *all* community colleges; an array of Guaranteed Transfer [69] courses to fulfill general education and prerequisite credits; and 60-credit associates of arts or sciences degrees [70]. Yet, in Colorado, as across the United States, transfer policy does not always translate into successful transfer practice [64].

UCB's fall 2010 enrollment was 29,954 [71]; at that time, community college transfer students took an average of 4.3 years to complete their engineering degrees, *after their 2+ years at the community college* [72]. Only a small number of courses—primarily basic math and science—were approved for transfer. No computer science or engineering courses had been evaluated. Essentially, every transfer student traveled a different path into our institution, and the paths were often arduous and slow.

In 2012, the state commission for higher education released a master plan, based in part on projections and gaps:

> According to the National Center for Higher Education Management Systems, consultants to Colorado's master planning process, Colorado would need to add approximately 1,000 additional postsecondary credentials each year to meet the 66 percent goal by 2025. Some expansion in postsecondary credential attainment will occur as a result of the state's expected population growth, which is predicted to increase by 20%, or about one million additional people, over the next decade. However natural growth alone will not result in the achievement of our 66 percent attainment goal [38].

Early in this century, extensive negotiations between Colorado's department of higher education, community colleges, and four-year institutions yielded a number of "degrees with designation" [73] (DWDs)—transfer degrees with foundational courses in specific program paths. With a DWD, a student could earn 60 general education credits in a community college, transfer to a university, earn 60 upper-division credits, and graduate with a bachelor's degree—nominally in four years' time. At this writing, nearly 40 statewide DWDs have been adopted. All public institutions participate in statewide articulation agreements, and some private institutions also

articulate credits from community colleges. However, the onus for navigating policy ramifications rests on students, who must know the policy *and* how to advocate for themselves. Unfortunately, what would appear to be straightforward on paper can be opaque to students [74].

The culture of higher education with gaps between systems [75] can challenge successful transfer [9]. This matters because having a robust policy environment was not adequate to support successful transfer. Doyle [76] found that 82% of transferring community college students who successfully migrated **all** their credits finished their bachelor's degree in six years. In contrast, only 42% of transferring community college students completed the baccalaureate degree in six years if their transfer credits **were not** accepted. State policy intended to facilitate transfer has its limits because decisions about which credits to accept or reject occur based on institutional preferences [77]. In our state, the higher-education departmental website directs students to work closely with advisors to improve their likelihood of transferring with needed prior coursework. Failing to do so, transfer students may become caught in systems that seem to defy achieving desired outcomes for the student, the state, and the institutions.

People

We discovered that unwavering focus from campus staff is urgently needed to help students to earn credentials and achieve their goals. In our change story, people are the super-heroes. The transformations we discuss result directly from the curiosity, hard work, and problem-solving efforts of a handful of people who performed beyond their "day jobs." We invite readers to think beyond titles, degrees, and roles. The actions of a few unlocked powerful changes on behalf of students. Who could help you achieve similar goals?

We chose identifiers for each person to describe their contemporaneous roles and detail how their actions took them beyond generic job descriptions or institutional pigeonholes. Four actors—the authors of this paper—have assigned roles to help tell this story, even though, over time, these actors have held many positions and fulfilled many responsibilities. We have assigned archetypal names, represented in italics: *Advisor*, *Spider*, *Dean*, *Engineering Educator*.

Cast

In 2013, the Academic *Advisor* joined UCB's mechanical engineering department with the credentials of a bachelor's degree in psychology and a master's degree in education. Prior to joining our team, he had been an advisor in a community college and was the *first* engineering-college staff member with work experience at a community college. With that lens, he quickly noticed a dearth of *community-college transfer* students. In 2014, the transfer-in rate of Colorado community college students to UCB was less than 7% [78]—an astonishingly low number considering UCB is the state's flagship university. In fact, at that time, most transfer students came from out-of-state four-year colleges.

The *Advisor* wanted to understand why. His professional network from the community college offered a tool to unravel transfer practices: he had easy access to former colleagues with direct responsibility for transfer success. His expertise and investigations soon led him into a new role with a specific focus on transfer students—the only such position on our entire campus.
He contacted the *Dean* of Math and Science at his former institution; her responsibilities at the time included transfer for students seeking bachelor's degrees in STEM. As a community college

Dean in a Hispanic Serving Institution, she had regular contact with the state's two- and four-year college administrators, policy experts in the state department of higher education, and students attempting to transfer. She had conducted and published STEM-focused education research and implemented research-based practices for students and through faculty development. At another engineering university, the *Dean* taught, conducted education research, and wrote the school's first plan to recruit faculty, staff, and students from different populations. She also served as a board member for an NSF-funded program to nurture youth interest in STEM. There, she met another board member from UCB's college of engineering, who managed a large K-12 engineering education program. Their collaboration expanded when the *Dean* was Co-PI for an NSF award that created an institutional navigator position to focus on community college transfer into the university. The fellow board member became the navigator, or *Spider*.

During her career at the flagship, the *Spider* had cultivated both deep experience and also a broad professional network which she brought into service of streamlining community-college transfer. The *Spider's* deliverables included untangling Colorado's web of STEM transfer into the university for Arts and Sciences and Engineering. She conducted a holistic review of campus transfer policy, processes, and practices. The *Spider* tracked down agreements, policies, data, and practices. She interviewed stakeholders internally and externally and also supported statewide events to uncover barriers and propose solutions. This work meant she worked closely with the *Advisor* in the engineering college and also frequently collaborated with the community college *Dean* to identify, address, and uncover problems which negatively impacted transfer.

Among the most important attributes of the *Spider* is tenacity; she met with resistance from many quarters, but her focus on student success, recognition of the ecosystem in which students navigated, and unrelenting attention to detail ensured that change occurred in key contexts.

The *Engineering Educator* directs an engineering program at UCB; he is deeply involved in how to improve belonging, identity, and student success in engineering. He recently was PI on an initiative to increase engineering bachelor's degree completion through transfer of community college students. This project contributed to the growing evidence of the importance of community college transfer pathways. One outcome was campus leaders' approval of formal articulation agreements for specific majors between community colleges and the flagship university. His academic preparation in engineering education and leadership position in the college inform both the operational and strategic aspects of our work.

These stakeholders understood that improving transfer could not rely exclusively on articulation agreements, more recruiting, or glossy brochures. Through their different professional experiences, they investigated what was at the core of transfer barriers, called on trusted colleagues for more information and support, and expanded their circle of influence.

Practices and processes

Identifying and agreeing on transfer basics—such as the foundational coursework between two- and four-year institutions—took time, energy, and diplomacy. As we systematically explored transfer mechanisms, we discovered disagreements about appropriate prerequisite coursework, doubts about community college quality, and ignorance about students' basic needs. Lesson one: policy—whether statewide or in each institution—was not enough to allow transfer to succeed. Policy is vulnerable to how broadly it is recognized and acted on; fundamentally, the practices

and processes institutional actors use can determine the success or failure of transfer students. Awareness, advocacy, and evidence were all critical to building new transfer paths; dedication and patience also helped.

Authentic partnerships—The *Advisor* recognized that hierarchies in the state's higher education ecosystem harmed transfer. In summer 2015, he initiated face-to-face meetings between the engineering college and local community colleges—*to be held on the community college campuses*. This step shifted an all-too familiar transfer dynamic: two-year colleges reach out to universities, not the other way around. The "listening tour" comprised engineering-college leaders, including the *Advisor*, Dean of Students, Dean of Inclusive Excellence, and the Director of Enrollment Management. Equivalent community college staff participated to collaborate on ways to better support transfer students. The 2015 listening tour fostered cultural change in the college of engineering. Nearly 10 years later and over the tenure of two college deans, transfer remains a priority in engineering.

Statewide convenings—A 2016 National Science Foundation award (#1649201) supported convenings of stakeholders from five universities, 15 two-year institutions, regional K-12 districts, and the state higher education department to identify problems in transfer and develop solutions. Action Research [55] practices engaged participants in a community to identify problems, brainstorm solutions, and implement new activities (see Appendix A).

We drew participants from many systems, sectors, institutions, roles, so it was incumbent on planners to minimize longstanding hierarchies. We invited expertise of folks doing the work at all levels and from across the state. Sessions were led by K-12 staff, community college administrators, two- and four-year faculty, and university leaders, with the goal of resetting expectations about UCB's role and responsibilities. Annual convenings over three years analyzed academic advising, transfer credit/admissions, policy, curricular learning outcomes, course transferability and degree applicability, communication, data, and financial aid, among others. Through wide-ranging expertise, insight, advice, and willingness to problem solve, we identified barriers and negotiated ways to solve them. These sessions engaged institutions across the state; led to more efficient transfer pathways with two- to four-year transfer agreements; and, finally, an associate in engineering science degree.

Creating the flagship's transfer vision—The *Spider* used NSF funding to create awareness, intention, and action regarding transfer campuswide. Her first order of business was educating UCB stakeholders about transfer as a distinct and deserving student population—its role in campus operations and the realities for transfer students. Cultural change was at the heart of her work as she launched working groups among faculty and staff. The *Spider* led iterative conversations to nurture new understanding, chiefly this: even if transfer students have earned prerequisite success in their community college, it does not mean they can innately navigate a new institution—particularly a large, complex university.

Faculty were wary of taking on new responsibilities and perceived that, because transfers arrive with prior college expertise, they did not need specific attention after matriculation. Shaping a faculty role in helping transfers choose appropriate courses proved to be persistently heated.

Building a community—The *Spider* also designed and implemented workshops between two- and four-year faculty to foster collaborative relationships. The *Dean* facilitated sessions during

these convenings to emphasize the value of coordinated contributions of all stakeholders to support transfer success. The workshops gave community college faculty direct contacts among university faculty whom they could reach out to with questions and share with prospective transfer students. The introductions also connected university faculty directly with their counterparts in two-year institutions, offering opportunities to establish trust. Breaking down barriers between systems was a powerful outcome from these convenings.

Statewide agreements and prerequisite policy—The *Dean* convened a meeting with community college STEM chairs and discipline chairs from a neighboring university to discuss how to improve transfer success. Degrees with Designation DWDs—transfer degrees approved by the state and all institutions—came up, yet the four-year chairs were baffled. Even though DWDs established prerequisite courses and assured that students could transfer as juniors and graduate within two more years, these STEM departments required different prerequisite courses to achieve junior status. This meant that transfer students into that university would need an additional academic year to complete their degrees. The *Dean* and two-year chairs added the courses to their curriculum and worked with advisors to better support students intending to transfer. The two-year chairs set up regular conferences with the university chairs to remain current on prerequisite expectations.

Held to different standards—The *Advisor* discovered that, based on habit rather than evidence, incoming community college transfers were held to stricter requirements than first-time, first-year students. Some university departments required transfers to *retake* calculus—in flagrant disregard of statewide Guaranteed Transfer policy negotiated by public two- and four-year campuses. He formed an engineering-transfer advising committee to craft and champion new admission requirements. The committee concentrated on refining transfer guides, smoothing pathways, and identifying strategies for advising prospective engineering transfers.

Student-centered processes—More than admissions criteria hampered engineering transfer student success. Incoming transfer students had to attend a two-day, on-campus orientation, modeled on orientation for new first-time, first-year students. This format stymied accepted transfer students who often juggled work and/or family commitments [9]. To support them, the *Advisor* designed and launched the first in-person transfer-specific orientations for engineering and organized campus visit programs for community college students—both of which considered transfer students' needs in their design and are initiatives that continue today.

Deficit thinking — In stakeholder meetings, the *Spider* and *Dean* experienced negative institutional beliefs about transfer. UCB faculty argued that they should not accept gateway course credits from community colleges because they "had heard that content was not rigorous enough," a common disparagement against community college quality [9]. Faculty, among them one department's Associate Chair, were unaware of the negotiated statewide agreements or the common course numbering protocol/guaranteed transfer course outlines. The department required transfer students to retake the gateway courses, adding time and cost to transfer students' degrees and violating statewide policy.

Lack of knowledge about students' lives—The *Dean* offered professional development for UCB faculty (see Figure 2) on ways to support transfer student success. Participants were in disbelief that not all university students were adequately housed, fed, and financially supported—in the "university town" in which the current median housing price is $954,000 [79]. (In fact, our

campus between September 2022 and November 2024, supported >670,000 pounds of food delivery through the food bank; >560,000 meals through various campus sites; <17,000 on-campus meals; and $2.6 million in saved grocery costs [80].)

Figure 2. Growth mindset workshop offered by the *Dean* for STEM faculty at the University of Colorado Boulder, September 2019.

Admittedly, we still lack a proven approach to help *each student* navigate through an equitable, effective process. However, we have learned this: we *must* ask the questions because paying careful attention to students' context supports them to earn their success.

Overall, by carefully analyzing and revising practices and processes of transfer, our team moved transfer discussions beyond expectations for a student to begin in institution "A" and migrate to institution "B." Our systems approach helped institutions across the state unravel some knots in transfer.

At UCB, we are seeing success in engineering. Even as transfer numbers are stagnant or declining elsewhere across our campus, for Fall 2024, our engineering college enrolled the *largest-ever* cohort of in-state community college students *and* the second-largest fall transfer cohort. Since fall 2010, overall engineering transfer student enrollment has grown 152% (25% increase in the last 5 years). In-state community college recruitment has grown from less than 20 students in 2010, to over 75 in 2024.

Products

Synergy—In this timeframe, the *Dean* convened her peers from five local community college campuses; their initial goal was to discuss and learn from one another the challenges and solutions they experienced in helping students transfer. They expanded on what they had learned from the *Spider* and the *Advisor* to hone in carefully on community college needs. They developed a community-college specific planning grant that was aligned with the UCB's transfer project (NSF Award Number #1812648).

Engineering-transfer dean—Collaborating with a mathematics faculty member from a nearby community college, the UCB team developed a campus-to-campus pre-engineering program. These guidelines ultimately proved instrumental in creating a statewide agreement because the resulting Point A (community college) to Point B (UCB) agreement became the test case. This two-year institution is a prime partner in transfer to the flagship. In demonstration of its seriousness to successful engineering transfer, the community college appointed this faculty member as the inaugural Dean of Mathematics and Engineering.

Ongoing impact—Our team used the 2016 NSF support to set the vision for institutional transformation and establish more effective practices and processes statewide. The *Spider* navigated both campus and state structures to establish and refine all STEM transfer guides (see Appendix B) in the College of Arts and Sciences. Some of these guides have been superseded, but many are still in use. At the state level, this innovation gave potential transfer students a foundation to begin their migration into our university.

Many initiatives, such as pre-transfer advising, expanded transfer guides, and transfer-specific orientations, have been adopted campus-wide, reflecting the sustained impact of these efforts. The Provost's Transfer Success Committee, originally launched by the *Spider* with 12-15 key stakeholders, has grown to ~40 faculty and staff who want to continue improving how UCB supports community college students. Among their innovations is careful attention to data so the campus can better understand persistence and completion of transfer students as well as implement appropriate interventions when data indicate that action is needed. The *Advisor* continues as Committee leader, carrying forward new support on behalf of transfer students.

Starting from scratch—We already knew that our own campus' deficit thinking hampered transfer, as we had learned when departments rejected community-college calculus coursework. However, to develop a measurable transfer process, we needed a baseline to understand what did and did not work regarding transfer. Building on what our team learned from statewide convenings, transfer success would have to be based in evidence, not prior practice. We used both qualitative and quantitative data to develop next steps.

In close collaboration with the university's Institutional Research team, the *Advisor* triangulated data on prior transfer students, including their earlier coursework **and** their post-transfer success. Then, he also reviewed existing course equivalencies using the two-year colleges' common course numbering and extant articulation agreements. After establishing an evidence-based foundation, the transfer committee in the college of engineering began to draft basic transfer guides. Working with academic departments, the team expanded the list of transfer-approved courses. The *Advisor* also built on the relationships he had established with community college

administrators, advisors, and faculty. These efforts laid the foundation for comprehensive engineering transfer guides for community college students in our state, although not until the distant future.

It took a village—and more than a decade—The *Advisor* and *Spider* proposed an initiative with Colorado's department of higher education, two-year colleges, and four-year institutions to create the structure for an associate of engineering sciences degree. In academic-year 2018-19, the state's department of higher education convened a group of faculty and staff from each engineering program to craft a statewide policy. Smaller meetings with each two- and four-year campus navigated the details. Stakeholders were mostly receptive—until programmatic idiosyncrasies and legislative complexities bogged down negotiations. Finally, a universal model was set aside in favor of major-specific pathways that could be articulated at the state level. This adaptation allowed *most* coursework to be accepted at all institutions while offering each campus appropriate discretion (see Appendix C). Throughout the statewide process, our original transfer guides served as the model (see Appendix D) [81].

After nearly *15 years of negotiation*, our state unveiled an engineering transfer agreement. The state's system of community colleges, two district colleges, and three primary engineering bachelor's institutions have signed on [82]. Other states have found that even directives from the governor's office have not been adequate to budge institutional cultures on behalf of transfer students [9]. This hard-won outcome is testament to the persistence, collaboration, and intentionality of our team.

Closer to home—In 2025, UCB's engineering college has the most articulated pathways of any engineering program in the state [81],[84]. Transfer student enrollment has steadily increased since 2017, even during the pandemic. In the 2023-2024 academic year, the transfer-in rate by Colorado community college students had increased to nearly 10%, and the persistence of this team began to be evident [78].

The *Advisor* recognized that it was not enough to make orientation more available to transfer students; the first semester could be difficult if students did not have more support. He started a transfer-student course paired with a mentoring program. The *Engineering Educator* sits on a guest panel for a transfer-student seminar course. As a panelist, he shares his own non-linear path to engineering and encourages students to engage with the hands-on activities and workshops of the program he directs to help them develop skills, belonging, and identity in engineering.

Some notable transfer data from the flagship's engineering program include

- Since 2010, our college has created a 152% increase in engineering enrollment of transfer students
- Since 2020, we have welcomed a 25% increase in transfer enrollment
- In fall 2024, transfer represented 25% of engineering's incoming class
- The majority of transfer student enrollment comes from state community colleges—unlike prior years in which out-of-state students dominated transfer
- Transfer students graduated at higher rates, 87%, than did first-year, first-time students,75.6%
- Transfer retention rates have improved from 85%, in 2015 to greater than 94% in 2024
- Since 2018-19, the average time-to-degree for transfers into engineering has dropped from 3.3 years to 2.5 years today.

Potential next steps

The powerful, positive impact of our team's work over the past number of years is clear in the story we have shared, yet we are not finished. Since 2019, the number of transfer students who left without a degree decreased by 10% [78], yet our system approach drives us to seek why transfer students leave without degrees. While 10% is progress, it is not enough. After two years of summer research internships, we need to understand how this program helped transfer students graduate and enter industry.

Beyond our own campus, we want to share the lessons we have learned—chief among them is that policy is not enough. Detailed articulation agreements help, yet they are not enough, either. After years of analyzing and discussing course equivalencies and crafting articulation agreements, our improvement came from a small group of people who were willing to ask questions, include others, refine and repair, and persist. Through dedication, curiosity, and collaboration, this team has learned to dismantle embedded barriers.

Limitations: We do not assert causality; rather, we describe our process. Nevertheless, we do hope that some of the lessons we learned could help others improve community college transfer. Even if our discussion is not generalizable, we hope that what we describe is transferable.

References

[1] University of Colorado Bouder, College of Engineering and Applied Science, Mission & Vision. [Online]. Available: https://www.colorado.edu/engineering/mission-vision. [Accessed Feb. 18, 2025].

[2] M. Koro-Ljungberg and E.P. Douglas. "State of Qualitative Research in Engineering Education: Meta-Analysis of JEE Articles, 2005–2006" Journal of Engineering Education, vol. 97, no. 2, pp. 163-175, April 2008. [Online]. Available: https://doi.org/0.1002/j.2168-9830.2008.tb00965.x. [Accessed Feb. 17, 2025].

[3] R. K. Yin. *Case study research design and methods (4th ed.).* Thousand Oaks, CA: Sage, 2009.

[4] R. K. Yin. *Case study research design and methods (5th ed.).* Thousand Oaks, CA: Sage, 2014.

[5] R. K. Yin. *Case study research design and methods (6th ed.).* Thousand Oaks, CA: Sage, 2018.

[6] J. Cleland, A. MacLeod A., and R.H. Ellaway. "The curious case of case study research," *Medical Education,* vol. 55, no. 10, pp. 1131–1141, 2021. [Online]. Available: https://doi.org/10.1111/medu.14544. [Accessed Feb. 17, 2025].

[7] D.R. Hess. "Retrospective studies and chart reviews," Respiratory Care, vol. 49, no. 10, pp. 1171-4. [Online]. PMID: 15447798.

[8] P. Mayo. "Praxis in Paulo Freire's emancipatory politics," *International Critical Thought*, vol. 10, no. 3, pp. 454–472, Dec. 2020. [Online]. Available: https://doi.org/10.1080/ 21598282.2020. 1846585. [Accessed Feb. 17, 2025].

[9] K.C. Senie. "Implementing transfer and articulation: A case study of community colleges and state universities," *Community College Journal of Research and Practice*, vol. 40, no. 4, pp. 269–284, Feb. 2015. [Online]. Available: https://doi.org/10.1080/10668926.2015.1038667. [Accessed Feb. 17, 2025].

[10] S. J. Handel. *Increasing higher education access and success using new pathways to the baccalaureate: The emergence of a transfer-affirming culture,* San Jose, CA: Western Regional Office, The College Board, 2011.

[11] S.J. Handel and R.A. Williams, *The promise of the transfer pathway: Opportunity and challenge for community college students seeking the baccalaureate degree.* New York, NY: The College Board Advocacy and Policy Center, Oct. 2012.

[12] R.C. Bogdan and S.K. Biklen. *Qualitative Research for Education: An Introduction to Theory and Methods, 5th Edition.* Boston, MA: Allyn & Bacon, 2007.

[13] S.A. Dumais and A. Ward, "Cultural capital and first-generation college success," *Poetics,* vol. 38, no. 3, pp. 245-265, June 2010. [Online]. Available: https://doi.org/10.1016/j.poetic.2009.11.011. [Accessed Feb. 20, 2025].

[14] B. K. Townsend and K. Wilson, "A hand to hold for a little bit: Factors facilitating the success of community college transfer students to a large research university," *Journal of College Student Development,* vol. 47, no. 4, pp. 439-456, 2006. [Online]. Available: https://doi.org/10.1353/csd.2006.0052. [Access Feb 20, 2025].

[15] D. D. Buie, "Beyond a deficit view: Understanding the experiences of first-generation students who participate in college access and success community-based organizations," Ed.D. dissertation, Aurora University, United States – Illinois, 2018. [Online]. Available: https://www.proquest.com/docview/2384858972/abstract/CD5B029B15BE4E11PQ/1. [Accessed Feb. 20, 2025].

[16] H. Jabbar, L. Schudde, M. Garza, and S. McKinnon-Crowley, "Bridges or barriers? How interactions between individuals and institutions condition community college transfer," *The Journal of Higher Education,* vol. 93, no. 3, pp. 375–398, Apr. 2022. [Online]. Available: https://doi.org/10.1080/00221546.2021.1953339. [Accessed Feb. 20, 2025].

[17] J. Koyama and S. Desjardin, "Building bridges and borders with deficit thinking," *Educ. Real,* vol. 44, p. e86415, Apr. 2019. [Online]. Available: https://doi.org/10.1590/2175-623686415. [Accessed Feb. 20, 2025].

[18] C. Heinbach, B. Paloma Fiedler, R. Mitola and E. Pattni. "Dismantling Deficit Thinking: A strengths-based inquiry into the experiences of transfer students in and out of academic libraries," *In the Library with the Lead Pipe,* Feb. 6, 2019. [Online]. Available: https://www.inthelibrarywiththeleadpipe.org/2019/dismantling-deficit-thinking/. [Accessed Feb. 20, 2025].

[19] C. Dudley-Marling, "The resilience of deficit thinking," *Journal of Teaching and Learning,* vol. 10, no. 1, 2015.

[20] X. Wang, "Educational expectations and progress of community college students: Does socialization matter?" *Teachers College Record,* vol. 118, no. 5, pp. 1–32, May 2016. [Online]. Available: https://doi.org/10.1177/016146811611800504. [Accessed Feb. 20, 2025].

[21] K. Moser, "Exploring the impact of transfer capital on community college transfer students," *Journal of The First-Year Experience & Students in Transition,* vol. 25, no. 2, pp. 53–76, Jan. 2013.

[22] C. Maliszewski Lukszo and S. Hayes, "Facilitating transfer student success: Exploring sources of transfer student capital," *Community College Review,* vol. 48, no. 1, pp. 31–54, Jan. 2020. [Online]. Available: https://doi.org/10.1177/0091552119876017. [Accessed Feb. 20, 2025].

[23] M. Bertrand and J. Marsh, "How data-driven reform can drive deficit thinking," *Phi Delta Kappan,* vol. 102, no. 8, pp. 35–39, May 2021. [Online]. Available: https://doi.org/10.1177/00317217211013936. [Accessed Feb. 20, 2025].

[24] A. Minichiello, "From deficit thinking to counter storying: A narrative inquiry of nontraditional student experience within undergraduate engineering education," *International Journal of Education in Mathematics, Science and Technology,* vol. 6, no. 3, pp. 266-284, 2018.

[25] S. J. Handel, "Second Chance, Not Second Class: A Blueprint for Community-College Transfer," *Change: The Magazine of Higher Learning,* Jan. 2007. [Online]. Available: https://www.tandfonline.com/doi/abs/10.3200/CHNG.39.5.38-45. [Accessed Feb. 20, 2025].

[26] X. Wang, Ed., *Studying transfer in higher education: new approaches to enduring and emerging topics,* San Francisco: Jossey-Bass, 2017.

[27] X. Wang, "Upward transfer in STEM fields of study: A new conceptual framework and survey instrument for institutional research," *New Directions for Institutional Research,* vol. 2016, no. 170, pp. 49–60, 2016. [Online]. Available: https://doi.org/10.1002/ir.20184. [Accessed Feb. 17, 2025].

[28] J. Fink and D. Jenkins, "Takes two to tango: Essential practices of highly effective transfer partnerships," *Community College Review,* vol. 45, no. 4, pp. 294–310, Oct. 2017. [Online]. Available: https://doi.org/10.1177/0091552117724512. [Accessed Feb. 20, 2025].

[29] J. Fink, Community College Research Center. "What We Know About Transfer Outcomes and How Colleges Can Improve Them," presentation to the New England Board of Higher Education Next Generation Transfer Event, Jan. 19, 2018. [Online]. Available: https://ccrc.tc.columbia.edu/presentation/what-we-know-transfer-outcomes-how-colleges-can-improve-them-nebhe.html. [Accessed Feb. 20, 2025].

[30] J. L. Taylor and D. Jain, "The multiple dimensions of transfer: Examining the transfer function in American higher education," *Community College Review,* vol. 45, no. 4, pp. 273–293, Oct. 2017. [Online]. Available: https://doi.org/10.1177/0091552117725177. [Accessed Apr. 24, 2025].

[31] J. Wyner, K. C. Deane, D. Jenkins, and J. Fink, *The Transfer Playbook: Essential Practices for Two- and Four-Year Colleges,* May 2016. [Online]. Available: https://ccrc.tc.columbia.edu/publications/transfer-playbook-essential-practices.html. [Accessed Feb. 17, 2025].

[32] Colorado Workforce Development Council. Education and Training: Talent Pipeline Report, spring edition 2024. [Online]. Available: https://drive.google.com/file/d/1t3OS5FEndZXIEhJtrVKrO0EslXUi1jcM/view. [Accessed Feb. 16, 2025].

[33] J. Gonzales. “Colorado Higher ed leaders to lawmakers: Funding isn’t keeping up with inflation.” Chalkbeat Colorado. [Online]. Available: https://www.chalkbeat.org/Colorado/2023/1/12/23552720/Colorado-2023-budget-colleges-universities-request-more-money/. [Accessed January 5, 2025].

[34] Georgetown University Center on Education and the Workforce. (2024). *After Everything: Projections of Jobs, Education, and Training Requirements through 2031.* [Online]. Available: https://cew.georgetown.edu/Projections2031. [Accessed Feb. 20, 2025].

[35] J. Gonzales. “Colorado leads the nation in college-educated residents, but gaps remain.” Chalkbeat Colorado. [Online]. Available: https://www.chalkbeat.org/Colorado/2024/02/06/stronger-nation-report-Colorado-leads-the-country-in-residents-college-attainment/. [Accessed Feb. 17, 2025].

[36] N. Hillman and T. Weichman. “Education deserts: The continued significance of ‘place’ in the twenty-first century.” Viewpoints: Voices from the Field. American Council on Education, (2016). [Online]. Available: https://www.acenet.edu/Documents/Education-Deserts-The-Continued-Significance-of-Place-in-the-Twenty-First-Century.pdf. [Accessed January 3, 2025].

[37] Scaling Partners Network. “Transfer and applicability of credit: Call to action.” [Online]. Available: https://www.utdanacenter.org/sites/default/files/2020-10/Scaling%20Partners%20Network%20-%20Transfer%20and%20Applicability%20of%20Credit%20-%20Call%20to%20Action%2010-26-20.pdf. [Accessed January 6, 2025].

[38] Colorado Rises: Advancing Education and Talent Development, Colorado Commission on Higher Education, Aug. 2017. [Online]. Available: https://highered.colorado.gov/Publications/Reports/cdhe-master-plan-2017.pdf. [Accessed Feb. 17, 2025].

[39] Colorado Community College System, Data and Reports, Enrollment, One Year Transfer Counts & Rates. [Online]. Available: https://cccs.edu/data/systemwide/transfers/. [Accessed Jan. 7, 2025].

[40] R.M. Gibbs. *College completion and return migration among rural youth,* in P. L. Swaim, R. Teixeria, N. Hillman, and T. Weichman. (2016). Education deserts: The continued significance of ‘place’ in the twenty-first century. *Viewpoints: Voices from the Field.* American Council on Education. Washington, DC. [Online]. Available: https://www.acenet.edu/Documents/Education-Deserts-The-Continued-Significance-of-Place-in-the-Twenty-First-Century.pdf. [Accessed February 17, 2025].

[41] National Student Clearinghouse Research Center. “Completing College – National – 2018.” [Online]. Available: https://nscresearchcenter.org/category/2018/. [Accessed January 14, 2025].

[42] S. Provasnik, A. Kewal Ramani, M.M. Coleman, L. Gilbertson, L., W. Herring, and Q. Xie. *Status of education in rural America* (NCES 2007-040). Washington, DC: National Center for Educational Statistics. Institute of Education Sciences, U.S. Department of Education, 2007.

[43] S-Y. Byun, J.L. Meece, and C.A. Agger. "Predictors of college attendance patterns of rural youth," *Research in Higher Education,* vol. 58, pp. 817-842, 2017.

[[44] R.S. Wells, C.A. Manly, S. Kommers, and E. Kimball, E. "Narrowed gaps and persistent challenges: Examining rural-nonrural disparities in postsecondary outcomes over time," *American Journal of Education,* vol. 126, no. 1, Nov. 2019. [Online]. Available: https://doi.org/10.1086/705498. [Accessed Apr. 24, 2025].

[45] M. Frenette. "Access to college and university: Does distance to school matter?" *Canadian Public Policy / Analyse de Politiques*, vol. 30, no. 4, pp. 427–443, 2004. [Online]. Available: https://doi.org/10.2307/3552523. [Accessed Apr. 24, 2025].

[46] S-Y. Byun, J.L. Meece and M.J. Irvin. "Rural-nonrural disparities in postsecondary educational attainment revisited." *American Educational Research Journal*, vol. 49, no. 3, pp. 412-437, 2012.

[47] A.N. Garza and A.S. Fullerton. "Staying close or going away: How distance to college impacts the educational attainment and academic performance of first-generation college students," *Sociological Perspectives*, vol. 61, no. 1, pp. 164-185, 2018. [Online]. Available: https://journals.sagepub.com/doi/abs/10.1177/0731121417711413?journalCode=spxb [Accessed Feb. 20, 2025].

[48] L. Knox. "A long way down the demographic cliff: The traditional college-age population will peak next year. Is higher education ready to face the coming decline?" *Inside Higher Ed,* Dec. 11, 2024. [Online]. Available: https://www.insidehighered.com/news/admissions/traditional-age/2024/12/11/college-age-demographics-begin-steady-projected-decline. [Accessed Feb. 17, 2025].

[49] J. Nabukenya, "Combining Case Study, Design Science and Action Research Methods for Effective Collaboration Engineering Research Efforts," *2012 45th Hawaii International Conference on System Sciences*, Maui, HI, USA, 2012, pp. 343-352, [Online]. Available: https://doi.org/10.1109/HICSS.2012.162. [Accessed Apr. 24,2025].

[50] A. Priya. "Case Study Methodology of Qualitative Research: Key Attributes and Navigating the Conundrums in Its Application," *Sociological Bulletin,* vol. 70, no. 1, pp. 94-110, 2021. [Online]. Available: https://doi.org/10.1177/0038022920970318. [Accessed Feb 17, 2025].

[51] "Quick start to case study research." In A. Mills, G. Durepos, E. Wiebe (Eds.) *Encyclopedia of case study research,* vol. 0, pp. 771-774, 2010. SAGE Publications, Inc. [Online]. Available: https://doi.org/10.4135/9781412957397. [Accessed Feb. 17, 2025].

[52] EvalCommunity. “Understanding impact evaluation: Definition, benefits, and best practices. [Online]. Available: https://www.evalcommunity.com/career-center/impact-evaluation/. [Accessed Feb. 17, 2025].

[53] J.W. Creswell and C. Poth. *Qualitative inquiry and research design: Choosing among five approaches, 4th ed.* London: Sage, 2007.

[54] D. de Vaus. *Research Design in Social Research.* London: Sage, 2001.

[55] M. Riel. “Understanding Action Research,” Center for Collaborative Action Research (CCAR), Apr 2024. [Online]. Available: https://www.ccarweb.org/what-is-action-research. [Accessed Feb 17, 2025].

[56] C. Adelman, “Kurt Lewin and the Origins of Action Research,” *Educational Action Research,* vol. 1, no. 1, pp. 7-24, 1993. [Online]. Available: https://doi.org/10.1080/0965079930010102. [Accessed Feb. 17, 2025].

[57] D. Bargal. “Personal and intellectual influences leading to Lewin’s paradigm of action research: Towards the 60th anniversary of Lewin’s ‘Action research and minority problems,” *Action Research,* vol. 4, no. 4, pp. 367-388, 2006. Sage Publications: Thousand Oaks, CA. [Online]. Available: https://doi.org/10.1177/1476750306070101. [Accessed Feb. 17, 2025].

[58] National Center for Education Statistics. IPEDS, National Student Clearing House, college/university/system data. [Online]. Available: https://nces.ed.gov/ipeds/datacenter/InstitutionByName.aspx?goToReportId=6&sid=08c77b73-2f92-42c8-9604-08bc27e7e0e0&rtid=6. [Accessed Feb. 19, 2025].

[59] H. Shaked and C. Schechter. “Definitions and development of systems thinking,” In: Systems thinking for school leaders. *SpringerNatureLink,* pp. 9-22, 2017. [Online]. Available: https://doi.org/10.1007/978-3-319-53571-5_2. [Accessed Feb. 17, 2025].

[60] L. Atkins and S. Wallace. “Discourse analysis and policy analysis,” in *Discourse analysis and policy analysis,* pp. 169-188, 2012. London: Sage. [Online]. Available: https://doi.org/0.4135/9781473957602. [Accessed Feb. 20, 2025].

[[61] S. Kodithuwakku. Qualitative methods for policy analysis: Case study research strategy, 2022. [Online]. Available: https:// doi:10.1007/978-981-16-3284-6_7. [Accessed Apr. 24, 2025].

[62] J. Browne, B. Coffey, K. Cook, S. Meiklejohn and C. Palermo. “A guide to policy analysis as a research method,” *Health promotion international,* vol. 34, 2018. [Online]. Available: https://doi.org/10.1093/heapro/day052. [Accessed Feb. 20, 2025].

[63] S. M. Kilonzo and A. Ojebode. “Research methods for public policy,” in: E.R. Aiyede and B. Muganda (eds). *Public Policy and Research in Africa.* Palgrave Macmillan, Cham., 2023. [Online]. Available: https://doi.org/10.1007/978-3-030-99724-3_4. [Accessed Feb. 17, 2025].

[64] T. LaViolet and J. Wyner. Beyond articulation agreements: Five student-centered principles to improve transfer," A Tackling Transfer Report. The Aspen Institute College Excellence Program. [Online]. Available: https://files.eric.ed.gov/fulltext/ED610361.pdf. [Accessed Feb. 17, 2025].

[65] Colorado Department of Higher Education. SMART act report. 2018. [Online]. Available: https://leg.colorado.gov/sites/default/files/images/cdhe_annual_performance _evaluation.pdf. [Accessed Feb. 20, 2025].

[66] Education Commission of the States. "50-state comparison," in Postsecondary governance structures 2020, Nov. 2020. [Online]. Available: https://reports.ecs.org/comparisons/postsecondary-governance-structures-2020-overviews-01. [Accessed Feb. 20, 2025].

[67] M. Fulton, "An Analysis of State Postsecondary Governance Structures," in Policy Guide, Education Commission of the States, Oct. 2019. [Online]. Available: https://files.eric.ed.gov/fulltext/ED598982.pdf. [Accessed Feb. 17, 2025].

[68] Colorado Community College System. *"SP9-71 – Community college course numbering system,"* Colorado Community College System/System Procedure, July 2001.

[69] Colorado Department of Higher Education. Credit transfer. State of Colorado, 2025. [Online]. Available: https://cdhe.colorado.gov/students/attending-college/credit-transfer. [Accessed Feb. 17, 2025].

[70] Colorado Department of Higher Education. Transfer degrees. State of Colorado, 2025. [Online]. Available: https://cdhe.colorado.gov/students/attending-college/credit-transfer. [Accessed Feb. 17, 2025].

[71] University of Colorado Boulder, Institutional Research. Historical enrollment since 1877, Feb. 6, 2025. [Online]. Available: https://public.tableau.com/app/profile/ university.of.colorado.boulder.ir/viz/HistoricalEnrollment-1877/Enrollment. [Accessed Feb. 17, 2025].

[72] Colorado Commission on Higher Education. "Colorado competes: A completion agenda for higher education," *Masterplan,* Oct. 2012. [Online]. Available: https://highered.colorado.gov/Publications/Reports/CDHE-Master-Plan-2012.pdf. [Accessed Feb. 20, 2025].

[73] Colorado Department of Higher Education. Transfer degrees. [Online]. Available: https://cdhe.colorado.gov/students/attending-college/credit-transfer/transfer-degrees. [Accessed Feb. 20, 2025].

[74] "Ensuring college readiness and applicability of credits earned during high school," Division of Student Success & Academic Affairs, Mar. 1, 2019. [Online]. Available: https://cdhe.colorado.gov/sites/highered/files/2020-03/cdhe-ensuring-college-readiness_0.pdf. [Accessed Feb. 17, 2025].

[75] S. Baime and S. Baum. Community colleges: Multiple missions, diverse student bodies, and a range of policy solutions," *Urban Institute,* pp. 1-20, Aug. 2016. [Online]. Available: https://files.eric.ed.gov/fulltext/ED570475.pdf. [Accessed Feb. 17, 2025].

[76] W.R. Doyle. "Community college transfers and college graduation: Whose choices matter most?" *Change: The Magazine of Higher Learning,* vol. 38, no. 3, pp. 56–58, 2006.

[77] C.M. Mullin. "Transfer: An indispensable part of the community college mission (Policy Brief 2012-03PBL)," 2012. Washington, DC: American Association of Community Colleges.

[78] *Data Reports.* University of Colorado Boulder, Data & Analytics, Office of Information Technology. [Online]. Available: https://data.colorado.edu/public-factbook. [Accessed Jan 11, 2025].

[79] Zillow. Zillow Home Value Index, Boulder, CO Housing Market. [Online]. Available: https://www.zillow.com/home-values/30543/boulder-co/?msockid=013cf209b381679b10c5e747b2bb668c. [Accessed Feb 17, 2025].

[80] University of Colorado Boulder. Basic Needs Center, Division of Student Affairs. [Online]. Available: https://www.colorado.edu/support/basicneeds/. [Accessed Feb. 20, 2025].

[81] University of Colorado Boulder, College of Engineering & Applied Science. Admissions, Transfer Students, Associate of Engineering Sciences Transfer Pathways. [Online]. Available: https://www.colorado.edu/engineering/admissions/transfer-students/colorado-community-colleges/associate-engineering-sciences-transfer. [Accessed Feb. 19, 2025].

[82] Colorado Community College System. *"A direct path to a career in engineering: Associate of engineering science."* [Online]. Available: https://cccs.edu/colleges-programs/programs/transfer-programs/associate-of-engineering-science/. [Accessed Feb. 19, 2025].

[83] Colorado Community College System. "CCCS, CU Boulder forge new engineering transfer pathways," *Press Release,* Feb. 28, 2024. [Online]. Available: https://cccs.edu/press-releases/cccs-cu-boulder-forge-new-engineering-transfer. [Accessed Feb. 20, 2025].

[84] University of Colorado Boulder, College of Arts and Sciences. Transfer guides for Colorado community college students, Physics (BA) academic course map. [Online]. Available: https://www.colorado.edu/artsandsciences/student-resources/transfer-students/guide-colorado-community-college-students/transfer-guides-by-major/neuroscience-ba-academic-course-map. [Accessed Feb. 21, 2025].

Appendix A. Executive Summary for the CU Boulder-led 2019 2- to 4-Year Transfer Summit.

University of Colorado Boulder

COLORADO
COMMUNITY COLLEGE SYSTEM

2019 2- TO 4-YEAR TRANSFER SUMMIT
EXECUTIVE SUMMARY

Event Details

The third annual *2- to 4-year Transfer Summit* was held Friday, March 15, 2019, at Front Range Community College's Westminster campus. Formerly known as the *CAPS Summit,* the event—co-hosted by the University of Colorado Boulder's College of Engineering and Applied Science and the Center for STEM Learning and the Colorado Community College System office—brought together stakeholders in Colorado invested in streamlining the process for community college students transferring to a four-year university to pursue a bachelor's degree, particularly within a science, technology, engineering or mathematics (STEM) field. The event was offered in collaboration with the Colorado Department of Higher Education

Registrations were received from 164 people, representing 13 community colleges, 9 public four-year universities, one public school district, one national lab, as well as government and business entities. A major snowstorm in the state two days before the event prevented travel from many people who were traveling from distant locations. Thus, 121 people were in attendance for the event. The final agenda is attached.

Keynote Address

CCCS Chancellor Joe Garcia provided an inspirational talk about the importance of our collective work. Upon telling pieces of his own personal story and journey through higher education, he shared a recent experience of riding his bike into headwinds and tailwinds. He noted on the ride outbound with a friend, despite being of a certain age and spending time in the office, he felt remarkably fit and capable. It was only on the return ride that he found himself dragging, working harder, pushing with much effort on the *same* road that he had ridden just earlier that day. What was the difference? He said, "It's a heck of a lot easier to ride with a tailwind than into a head wind!" With this, Chancellor Garcia encouraged attendees to think about the tailwinds and headwinds that our students face as they encounter the "same" educational system. Noting the recent, pervasive admissions scandals, we find that students of privilege often are riding with a tailwind, whether they know it or not. And students, often first generation, students of color, and low income are facing what can often be severe headwinds. Students have forces working with them *and* against them, and Garcia reminded us to, whenever possible, to recognize the resources we provide students, and to assist *all* students navigate their journeys through higher education. Equity in education will depend on our addressing not only upon the "same" journeys that students are taking but the tailwinds and headwinds that they encounter along the way. Thank you, Chancellor Garcia!

Flash Talks

- CSU (Heather Matthews)—on how transfer guides help their Bridges to Baccalaureate program by creating a 4-click transfer pathway for 2YC students transferring into CSU.
- ACC (Michael McArthur)—on their new 120 credit hour RN to BSN program.
- Colorado Education Initiative (Alex Carter)—on the importance of strategic K-12 recruitment to bridge the gap in STEM pursuits between K-12 and higher education statewide.
- CCA (Victor Vialpando)—on their innovative math preparation model which brings all STEM identified students up to calculus readiness in one year.
- CU Denver (Camden Farmer)—on their accelerated transfer evaluation policy for 2YC transfer students.

Presentations

Colorado Department of Higher Education

Colorado's master plan—called *COLORADO RISES*—has the goals of: increasing completion, erasing equity gaps, improving student success, and investing in affordable innovation to reach a 66% statewide credentials attainment by 2025 for our adult population. More information at: http://masterplan.highered.colorado.gov/

Currently, Colorado has 34 Statewide Transfer Articulation Agreements (STAAs). *Did you know? All STAAs include a DwD and all DwDs are part of an STAA.* In 2018, 1/3 of all AA/AS degrees awarded were DwDs. Over 5,000 DwDs have been awarded to date. From 2011-2018, there have been 1,500 DwDs in

business, yet only 47 in biology. Why the difference? Do DwDs make a different in transfer and are they worth it? Yes.

- 59% vs. 50% are more likely to transfer into a four-year degree if they complete a DwD
- 42% vs. 29% are more likely to earn a BA within three years if they earn a DwD
- Students with a DwD are able to take four fewer credits in completing a BA than without the DwD

Reverse Transfer—There are 16 states in the US that offer "credit when it's due" (CWID), aka reverse transfer, with Colorado being one of nine states with legislation in place around reverse transfer. Senate Bill 12-045 passed unanimously in Colorado, allowing students to combine their credits from both community and four-year colleges to qualify for an associate's degree. Nearly 45% of students transfer *without* an associate's degree. By 2016, nearly 16k degrees had been awarded by reverse transfer nationally. In Colorado, 1,400 students have been awarded the associate degree by reverse transfer.

Discussion—With regard to the [interrupted] response from CDHE to the comment about how out-of-state credit transferred into a 2-year degree would be assessed by a 4-year school, CDHE replied with the following:

> "Once a public institution in Colorado awards and transcripts credit for a GT-Pathways requirement, that credit must be accepted by any public institution in the state. It matters not where or how the credit was earned—whether through a course taken at a Colorado public institution, or a course taken at another institution, or through prior learning assessment, or via a challenge exam. In all of these cases, an institution is assessing the comparability and equivalency of the course taken (or the learning experience gained) to the content criteria and competencies of a particular GT-Pathways category, and awarding credit based on this assessment. Another institution reviewing this in transfer cannot "un-accept" the credit that was awarded."

Note that this applies only to GT Pathways requirements, and not to other general education or major requirements, or to elective courses, at the receiving institution. If you have additional questions, please contact Dr. Chris Rasmussen, Director of Academic Affairs, CDHE (chris.rasmussen@dhe.state.co.us).

Colorado Community College System

CCCS provided a brief presentation on the demographics of students attending Colorado's 2-year colleges. *Did you know? More than 50% of nurses, and nearly 90% of first-responders receive their training at one of CCCS' 13 2-year colleges.*

CCCS' strategic priorities are: student success, equity, and concurrent enrollment, with impact metrics including a shift to learning indicators and away from FTE/headcount. There is a new focus on what happens when the student leaves the 2-year system.

Approximately 137k students attend one of the 13 colleges in the system, with ~120k being credit students. There are 103k high school CTE students, and more than 25k concurrent enrollment students. The average age of enrolled students is 25 and 55% are female. Not surprisingly, 94% of students are residents of Colorado, with 7k being veterans and 35% (or 43k) being students of color (21% Hispanic). CCCS serves 48% of all students of color in the state of Colorado, with the percentage of enrollment increasing since 2013. In 2017-2018, 46% of students received financial aid, down from the previous seven years.

52% of credentials earned are 1-year certificates, followed by the AAS, the AA, and finally the AS. The overall graduation rate (for all 13 colleges) is 25.6%. Morgan Community College has the highest graduation rate (47%) of all 2-year colleges in CCCS, followed by Trinidad State Junior College (45%).

Since 2014-2015, the overall number of transfer students who successfully transferred to 4-year university decreased slightly from ~8,500 to 7,600, with 6,400 staying in-state. In 2016-2017, Metro State University received the most transfer students (1,800), followed by CU Denver (939) and CSU (847).

Wisconsin Hope Lab reports that 42% of community college students experience food insecurity, 46% are housing insecure, and 12% are homeless. There are huge disparities between demographic groups and has a definite impact on students' grades. For more information see: https://hope4college.com/wp-content/uploads/2018/09/Wisconsin-HOPE-Lab-Still-Hungry-and-Homeless.pdf

Breakout Working Sessions

Following are high-level notes from each of the breakout working sessions throughout the day:

Transfer Guides Unpacked—While state agreements are important (DwDs, STAAs, Institutional agreements, course catalogs), students don't know the difference between them. Also, resources may make

things seem overly simple, and other institutional requirements can complicate transfer. Although resources can get outdated, institutional specific transfer guides can help reframe students' expectations about the remaining years of their education after transfer. ***Big Idea:*** put transfer guides into all 4-year college catalogues (CDHE has a link to all institutional catalogues).

Panel Discussion: Creating a STEM Pathway—There was much focus on placing more emphasis on figuring out an engineering pathway earlier, including adding math into other course curricula, similar to the way in which English has been added into courses throughout the curriculum. Also, the idea was raised to revise DwDs to include two or three program-specific courses for those intending a STEM major and to remove some of the courses that are not needed. ***Big Idea:*** create an engineering core that transfers to all 4YCs and all departments; also focus on sequencing of courses (i.e., calculus + engineering courses) and include meaningful work and internships.

Note: CDHE has added an Engineering articulation discussion to their 2019 Fac-to-Fac conference taking place all day Friday, April 26, 2019 at ACC. Although registration has closed for this event, information can be accessed at: https://highered.colorado.gov/Academics/Transfers/Conference/schedule.html. *If you are a faculty member, Dean or department chair, your future contributions to the conversation are encouraged.*

Focus on the Students—It's challenging to create a sense of belonging for transfer students; they are often perceived as being "unready" and not adequately prepared for university course work. How do we make our campuses a student-ready college as opposed to expecting a college-ready student? ***Big Idea:*** honor students' start dates at 2YC to protect them from curriculum and program changes; offer a transfer bridge program; create detailed degree plans for ALL pathways.

Best Practices for 2YC Data Collection—This session discussed the need to find ways to share data both ways—2-year to 4-year and vice versa. Both faculty/advisors/admin *and* students want to know about transfer student success. ***Big Idea:*** Create a standard set of summary statistics for all 4YCs to share with 2YC homes.

Birds of a Feather—

- *Curriculum Alignment*—The facts that each 4-year school is different and that degree requirements change from year-to-year makes it impossible for 2YC students to keep up. ***Big Ideas:*** Have articulation agreements carry over from 4YCs to lock-in at 4YCs; have curriculum-to-curriculum discussions of expected course outcomes; provide better communication from 4YCs to 2YCs on degree changes.
- *Policy*—Policy decisions are made at the state level, but then it is up to each individual institution to figure out how to make it happen. There should be better pathways for students with an AAS degree to transfer into 4YCs (either 2+3 programs and/or better engineering technology/programming pathway). ***Big Idea:*** Better/higher funding for faculty/staff retention.
- *Credit Transfer*—The CU system could have a common course numbering system, particularly for a first-year course. Faculty who are tasked with reviewing credits for transfer need to have a better understanding of the importance of their evaluations. ***Big Ideas:*** Apply degree requirements from year of student's educational journey; 2YC and 4YC discuss and agree upon learning objectives and course outcomes (to help with seamless transfer); CDHE should offer space on their website for changes to 4YC curriculum.
- *Culture*—Equip students with an awareness about the differences between 2- and 4YCs (e.g., a parking fee is not included at the 4YC, the "sense of belonging" process starts over, dorm life, class size, etc.); some of this should come from the 2YC level. Also, inform students about opportunities available to them. ***Big Ideas:*** Change the expectations of staff; provide definition of a Transfer Student; offer an in-person orientation to help students get through the first-semester transfer shock.

Transfer Equity and Inclusive Excellence—How do we get more students to transfer? Remove barriers, eliminate (or reduce) the imposter syndrome, and reduce the number of clicks transfer students have to make to get information. Offer opportunities for 2YCs at 4YCs that are flexible and fit students' lives. ***Big Ideas:*** Create a Transfer Center at each 2- and 4YC so that all communicate with one another; build student cohorts before leaving the 2YC; build the "freshman experience" for transfer students (i.e., through a 1-credit class, such as CSU has done).

Systems Alignment & Coordinating Math Curricula for Student Success—Some departments have unnecessary math pre-requisites that prevent students from succeeding. There is a general tension between

general and contextualized courses. ***Big Ideas:*** 4YCs should share the pass rates for transfer students with 2YCs; faculty from across the state should meet to agree upon and align math content, learning objectives, and pedagogies; there should be one champion at each school.

VALUING STUDENT'S VOICES—There are so many resources at a 4YC that it's overwhelming and confusing for transfer students; the confusion is paralyzing. It's important to include transfer awareness into all faculty/staff training. ***Big Ideas:*** Create a better mechanism for communication between institutions; provide on-demand data; create and externship program (i.e., visit another institution for a day/week).

Post-Summit Feedback

We heard you! As a result of the feedback received after the summit from 55% of the participants, several follow-up action items will occur in the next few months so that we may move the needle on 2- to 4-year transfer in our state. *We thank those of you who took the time to provide feedback.* This **Executive Summary** was created at the suggestion of several participants. Other upcoming "to dos" are:

- *2:4 Quarterly Newsletter* – our team will take the lead in creating a newsletter to share news and opportunities for 2YC and 4YC students, staff and faculty, as well as keep you up-to-date on happenings at CDHE, CCCS and around the state. As this newsletter rolls out, we will provide a platform for you to contribute newsworthy items to share. The newsletters will be emailed to a distribution list (recipients may opt-out if they choose) and posted on the CAPS website: www.colorado.edu/stempathways.

  The newsletter will also include: communication on the process and deadlines for submission of applications, and notice of upcoming meetings that are relevant to transfer practitioners.

- *Common Data Sharing* – We received a lot of feedback on the importance of sharing data. The response was high to the idea of creating a Colorado 2:4 Data Subcommittee; this initiative will be investigated in collaboration with CDHE and CCCS.

  Also, in the *2:4 Quarterly Newsletter,* we will showcase CU Boulder's institutional data on transfer student success and will invite all institutions to provide their data to share with the community. Data will also be regularly posted to the CAPS website.

- *Improved Math Alignment* – CDHE already has a Math Pathways Taskforce in place; we will work with CDHE to facilitate co-institutional meetings and communicate the outcomes of their initiative. Also, we will share key data on math pathways, including national data, upcoming math meetings.

- *Transfer Webinars/Digital Meetings* – In an effort to include our more distant partners, we will host 3-4 webinars and/or virtual meetings throughout the year. We welcome any suggestions for presenters and topics/institutions to showcase. Look for information in the *2:4 Newsletter.*

2020 Summit

Next year's Summit will be hosted by CCCS, in collaboration with CU Boulder. As soon as the date is finalized, it will be announced in the *2:4 Newsletter.* Stay tuned for more information.

For more information, please contact:

Janet Yowell
Director of Strategic Community College STEM Initiatives
Project Director, CU Boulder NSF INCLUDES and RET Programs
University of Colorado Boulder | College of Engineering and Applied Science
and the Center for STEM Learning
janet.yowell@colorado.edu

This material is based upon work supported by the National Science Foundation under Grant No. 1649201.

Appendix B. CU Boulder College of Arts & Sciences, sample STEM transfer guide, still in use

today [84].

CCD to CU Boulder Academic Course Map for Integrative Physiology (B.A.)

College of Arts and Sciences

Integrative Physiology Department Website

Program Overview

Students in CU Boulder's Department of Integrative Physiology study organisms as functioning systems of molecules, cells, tissues, and organs. This emphasis on whole-body function, and its applications to human health and disease, has made Integrative Physiology the second-largest undergraduate major at CU Boulder.

IPHY is a popular choice for students planning to pursue a health career, such as nursing, physician assistant, physical therapy, medicine, osteopathic medicine, exercise management, and physical education, or to attend medical school. Although the IPHY major does not cover all of the potential prerequisite courses needed for a health program, it provides students with integrated knowledge in disciplines such as, anatomy, biochemistry, mathematics, physics, physiology, and statistics to study how humans and other animals function at the level of genes, cells, tissues, organs, and systems. With this basic knowledge, students can undertake a flexible curriculum that includes the study of biomechanics, cell physiology, endocrinology, immunology, exercise physiology and neurophysiology. The department also encourages student participation in research. The program emphasizes both the role of physical activity in human health and function across the lifespan and the responses of different organisms to various forms of stress.

Their diverse faculty include several who have joint affiliations with the Institute for Behavioral Genetics and the Center for Neuroscience, as well as clinical divisions at the CU Anschutz medical campus.

Admission Requirements

Please see the following website for more information regarding transfer from a Colorado community college to CU Boulder's College of Arts & Sciences (https://www.colorado.edu/artsandsciences/student-resources/transfer-students/guide-colorado-community-college-students). This guide assumes successful completion of the MAPS (Minimum Academic Preparation Standards) requirements, as explained below.

MAPS (Minimum Academic Preparation Standards) Requirements

CU Boulder's College of Arts & Sciences expects incoming student to have completed the following course work while in high school; if a student has not, they are required to rectify this deficiency by completing additional college-level courses.

1) 3 years of English
2) 4 years of Mathematics
3) 3 years of Natural Science, including 1 year of Chemistry or Physics
4) 3 years of Social Science, including 1 year of U.S. or World History and 1 year of Geography
5) 3 years of the same Foreign Language

Students matriculating at CU Boulder with a MAPS deficiency are required to take additional courses at CU to rectify that deficiency even though they might have completed all their CU General Education requirements by earning an Associate's degree at the Community College of Denver.

Transfer Recommendations

To graduate in a 4-year overall time frame, it is important that students follow the recommended schedule below. Students who wish to continue their education at the community college beyond the number of credits specified below should explore with both community college and CU Boulder staff how their graduation timeline, COF stipend, and financial aid will be affected. ***Do not take Anatomy and Physiology courses at your community college.***

Suggested Four-Year Course Plan for Integrative Physiology

This is a suggested guide of coursework only and is subject to change. Always consult your academic advisor for graduation planning purposes. ***Depending on a student's situation, a different plan might be more applicable.***

Community College of Denver (first two years)

Fall Semester 1

Course	Course Title	Credits
ENG 121	English Composition I: GT-CO1	3
BIO 111	General College Biology I with Lab: GT-SC1	5
CHE 101[1]	Introduction to Chemistry I with Lab: GT-SC1	5
MAT 135	Intro to Statistics	3
	Total Credits	**16**

Spring Semester 1

Course	Course Title	Credits
ENG 122	English Composition II: GT-CO2	3
BIO 112	Gen College Biology II with Lab: GT-SC1	5
CHE 111	General College Chemistry I with Lab: GT-SC1	5
Guaranteed Transfer Social & Behavioral Sciences Course (GT-SS1, GT-SS2, GT-SS3)		3
	Total Credits	**16**

Fall Semester 2

Course	Course Title	Credits
CHE 112	General College Chemistry II with Lab: GT-SC1	5
Guaranteed Transfer Social & Behavioral Sciences Course (GT-SS1, GT-SS2, GT-SS3)		3
Guaranteed Transfer Arts & Humanities Course (GT-AH1, GT-AH2, GT-AH3, GT-AH4)		3
Guaranteed Transfer History Course (GT-HI1)		3
	Total Credits	**14**

Spring Semester 2

Course	Course Title	Credits
PHY 111	Physics: Algebra-based I, with Lab	5
COM 115 OR COM 125 OR COM 220	Public Speaking OR Interpersonal Communication OR Intercultural Communication	3
Guaranteed Transfer Arts & Humanities Course from a different area than the first GT-AH course		3
Guaranteed Transfer Course from any of the following categories (GT-AH1, GT-AH2, GT-AH3, GT-AH4, GT-HI1, GT-SS1, GT-SS2, GT-SS3)		3
	Total Credits	**14**

Total credits at the Community College of Denver **60**

Completion of the above coursework fulfills the requirements for an Associates of Arts Degree at the Community College of Denver, which fulfills the General Education requirements at CU Boulder.

CU Boulder (last two years)

Fall Semester 3

Course	Course Title	Credits
IPHY 3410	Introduction to Human Anatomy	3
IPHY 3415	Human Anatomy Laboratory (recommended but not required)	2
IPHY 3280	Introduction to Data Science and Biostatistics	4
Non-Major Elective		3
Non-Major Elective		3
	Total Credits	**15**

Spring Semester 3

Course	Course Title	Credits
IPHY 3430	Human Physiology	4
IPHY 3435	Human Physiology Laboratory	2
Non-Major Elective		3
Non-Major Elective		3
Upper Division Non-Major Elective		3
	Total Credits	**15**

Fall Semester 4

Course	Course Title	Credits
Advanced IPHY Course #1		4-5
Advanced IPHY Course #2		4-5
Upper Division Non-Major Elective		3
Upper-division Elective		3
Total Credits		**14-16**

Spring Semester 4

Course	Course Title	Credits
Advanced IPHY Course #3		3-4
Advanced IPHY Course #4		3-4
Advanced IPHY Course #5 (if needed)[2] or Upper-division Elective		3-4
Upper Division Non-Major Elective		3
Non-Major Elective (if needed to reach 120 total credits		3
	Total Credits	**15-18**

Total credits at CU Boulder **60-64**

Completion of all the above coursework fulfills the requirements for a Bachelor's Degree at CU Boulder.

[1] Prep course for CHE 111 General College Chemistry. If student can start with CHE 111, replace credits with approved AS electives but NOT BIO 201 or 202.

[2] Students must complete 15 credits in Advanced IPHY Courses but these courses vary from 3 to 5 credits so the number of courses needed will vary depending on the courses that are chosen.

Appendix C. Community college to CU Boulder, course articulation matrices.

Colorado Community College Transfer Advising Plan 2014/2015

University of Colorado **Boulder**

CU-Boulder College of Engineering and Applied Science

COMMUNITY COLLEGE TRANSFER COURSES	Required for CU-Boulder Engineering Degree Program													CU-BOULDER COURSE CODE
	Aerospace Engineering Sciences	Applied Mathematics	Architectural Engineering	Chemical & Biological Engineering	Chemical Engineering	Civil Engineering	Computer Science	Electrical & Computer Engineering	Electrical Engineering	Engineering Physics	Environmental Engineering	General Engineering Plus	Mechanical Engineering	
MATHEMATICS COURSES														
MAT 201 Calculus I (5cr.)	X	X	X	X	X	X	X	X	X	X	X	X	X	MATH 1300
MAT 202 Calculus II (5cr.)	X	X	X	X	X	X	X	X	X	X	X	X	X	MATH 2300
MAT 203 Calculus III (4cr.) OR MAT 204 Calculus III/Engineering App (5cr.)	X	X	X	X	X	X		X	X	X	X	X	X	MATH 2400
MAT 255 Linear Algebra (3cr.)	**Must take MAT 255 + MAT 265 to count as APPM 2360 at CU. Computer Science will take MAT 255 on its own.													
MAT 265 Differential Equations (3cr.)														
MAT 266 Diff. Equations AND Lin. Alg (4cr.)**	X	X	X	X	X	X		X	X	X	X	X	X	APPM 2360
** *All majors (except for Computer Science) may complete MATH 266-4, or MATH 255-3 plus (MATH 261-4 or MATH 265-3), to satisfy the Differential Equations with Linear Algebra requirement for the CU-Boulder College of Engineering & Applied Science.*														
SCIENCE COURSES														
BIO 111 General College Biology I (5 cr.)				X	X		Varies Depending on Track	or CHE 111	or CHE 111			or CHE 111		EBIO 1210/1230
BIO 112 General College Biology II (5 cr.)				X	X									EBIO 1220/1240
CHE 111 General College Chemistry I (5 cr.)		X	X	X	X	X		or BIO 111	or BIO 111	X	X	or BIO 111	X	CHEM 1113/1114
CHE 112 General College Chemistry II (5 cr.)				X	X					X	X			CHEM 1133/1134
CHE 211 Organic Chemistry I w/lab (5cr.)				X	X								Environmental track	CHEM 3311/3321
PHY 211 Physics: Calculus Based I (5 cr.)	X	X	X	X	X	X		X	X	X	X	X	X	PHYS 1110
PHY 212 Physics: Calculus Based II (5 cr.)	X	X	X	X	X	X		X	X	X	X	X	X	PHYS 1120
COMPUTER SCIENCE COURSES														
EGG 130 Intro to Engineering Computing (3cr.)	or CSC 160	or CSC 160	X	X	X	X					X	or CSC 160	or CSC 160	COEN 1300
CSC 160 Computer Science I (4cr.)	or EGG 130	or EGG 130					X	X	X	X		or EGG 130	or EGG 130	CSCI 1300
CSC 161 Computer Science II (4cr.)							X	X		or MCEN 1025 equiv.			X	CSCI 2270
CSC 165 Discrete Structures (4cr.)							X	X						CSCI 2824
CSC 225 Computer Arch & Assembly Lang. (4cr.)							X	X						CSCI 2400
ADDITIONAL ENGINEERING COURSES														
AEC 220 Surveying (3cr.)		Varies Depending on Specific Emphasis Area	X			X						Varies Depending on Track		CVEN 2012
AEC 221 Building Electrical/Mech. Syst. (3cr.)			X			X								AREN 2050
CAD 101+102 OR 201 - Computer Aided Drafting			X							or CSC 161				AREN 1027
CAD 255 or 256 or 257 or 258 or 259 - SolidWorks										or CSC 161			X	MCEN 1025*
EGG 100 Intro to Engineering (1cr.)	X		X	X	X	X	X	X	X	X (engr elective)	X		X	COEN 1500
EGG 101 Engineering Graphics (3cr.)			X											AREN 1027
EGG 140 Engineering Projects (3cr.)	X		X			X		X	X	X (engr elective)	X		X	GEEN 1400
EGG 206 Mechanics of Solids (3cr.)			X			X				X (engr elective)			X	MCEN 2063 OR CVEN 3161
EGG 211 Engineering Mechanics I -Statics (3cr.)			or EGG 271			or EGG 271				or EGG 271	or EGG 271		or EGG 271	MCEN 2023 OR CVEN 2121
EGG 212 Engineering Mechanics II -Dynamics (3cr.)			or EGG 272			or EGG 272				or EGG 272			or EGG 272	MCEN 2043 OR CVEN 3111
EGG 230 Thermodynamics (3cr.)			X			X				X (engr elective)	X		X	MCEN 3012 OR AREN 2110
EGG 271 Theoretical Mechanics-Statics (3cr.)			or EGG 211			or EGG 211				or EGG 211	or EGG 211		or EGG 211	MCEN 2023 OR CVEN 2121
EGG 272 Theoretical Mechanics-Dynamics (3cr.)			or EGG 212			or EGG 212				or EGG 212			or EGG 212	MCEN 2043 OR CVEN 3111
Note: All above coursework indicated with an X indicates that it will transfer to CU-Boulder; however, this does not mean that all checked coursework is required prior to admission - please contact the department for specific curriculum details and course applicability to each specific major.														
GENERAL EDUCATION COURSES - HUMANITIES/SOCIAL SCIENCES (H/SS) EQUIVALENTS														
ENG 121 English Composition I (3cr.) ENG 122 English Composition II (3cr.)	*NOTE: ENG 121 & 122 only count as a Free Elective in all majors of the College of Engineering and Applied Science. The number of Free Elective credits varies by department, but is generally 1-4 credit hours. Both courses are still strongly considered for better preperation in subsequent coursework and both are required for statewide A.A. and A.S. degrees.*													
All College of Engineering and Applied Science Humanities and Social Science courses should be taken from the approved list. This CCCS equivalent list can be found at: http://www.colorado.edu/engineering/admissions/transfer														
NOTE: CU-Boulder courses accepted by the College of Engineering and Applied Science can also be found at ***www.colorado.edu/engineering/academics/policies/hss***														

ADDITIONAL NOTES:

*Grades of a C- or higher are required to transfer to CU-Boulder. However, individual departments may have higher grade requirements for select courses. Please consult with an academic advisor in your intended transfer program to be aware of all policies and transfer credit details.

*Table prepared February 2014 and shows Colorado Community College courses that may be applied to specific majors for matriculants into CU-Boulder College of Engineering and Applied Science during the 2014-2015 academic year.

Colorado Community College Transfer Advising Plan 2014/2015

University of Colorado Boulder

CU-Boulder College of Engineering and Applied Science

COMMUNITY COLLEGE TRANSFER COURSES	Colorado Community Colleges														CU-BOULDER COURSE CODE
	Arapahoe Community College	Colorado Northwestern CC	Community College of Aurora	Community College of Denver	Colorado Mountain College	Front Range Community College	Lamar Community College	Morgan Community College	Northeastern Junior College	Pikes Peak Community College	Pueblo Community College	Red Rocks Community College	Trinidad State Junior College	CCC Online Courses	
Course offerings listed below are subject to change and are determined by each individual community college. Check with your intended community college prior to enrolling to ensure accurate course offerings															
MATHEMATICS COURSES															
MAT 201 Calculus I (5cr.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	MATH 1300
MAT 202 Calculus II (5cr.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	MATH 2300
MAT 203 Calculus III (4cr.) OR MAT 204 Calculus III/Engineering App (5cr.)	X	X	Both MAT 203 & 204	MAT 204 Only	X	Both MAT 203 & 204	X	X	X	X	X	MAT 204 Only	Both MAT 203 & 204	X	MATH 2400
MAT 255 Linear Algebra (3cr.)	**Must take MAT 255 + MAT 265 to count as APPM 2360 at CU. Computer Science will take MAT 255 on its own.														
MAT 265 Differential Equations (3cr.)															
MAT 266 Diff. Equations AND Lin. Alg (4cr.)**			X	X	X	X									APPM 2360
** All majors (except for Computer Science) may complete MATH 266-4, or MATH 255-3 plus (MATH 261-4 or MATH 265-3), to satisfy the Differential Equations with Linear Algebra requirement in the CU-Boulder College of Engineering & Applied Science.															
SCIENCE COURSES															
BIO 111 General College Biology I (5 cr.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	EBIO 1210/1230
BIO 112 General College Biology II (5 cr.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	EBIO 1220/1240
CHE 111 General College Chemistry I (5 cr.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	CHEM1113/1114
CHE 112 General College Chemistry II (5 cr.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	CHEM 1133/1134
CHE 211 Organic Chemistry I w/ lab (5cr.)	X		X	X		X			X	X		X			CHEM 3311/3321
PHY 211 Physics: Calculus Based I (5 cr.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	PHYS 1110
PHY 212 Physics: Calculus Based II (5 cr.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	PHYS 1120
COMPUTER SCIENCE COURSES															
EGG 130 Intro to Engineering Computing (3cr.)	Varies by individual community colleges from each semester - Same as CSC 160														COEN 1300
CSC 160 Computer Science I (4cr.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	CSCI 1300
CSC 161 Computer Science II (4cr.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	CSCI 2270
CSC 165 Discrete Structures (4cr.)												X		X	CSCI 2824
CSC 225 Computer Arch & Assembly Lang. (4cr.)			X			X				X				X	CSCI 2400
ADDITIONAL ENGINEERING COURSES															
AEC 220 Surveying (3cr.)	X									X					CVEN 2012
AEC 221 Building Electrical/Mech. Syst. (3cr.)						X				X					AREN 2050
CAD 101+102 OR 201 - Computer Aided Drafting	X	except 201		X	X	X	except 201			X	except 201	X			AREN 1027
CAD 255 or 256 or 257 or 258 or 259 - SolidWorks	X			X	X	X				X	X	X			MCEN 1025*
EGG 100 Intro to Engineering (1cr.)	X										X				COEN 1500
EGG 101 Engineering Graphics (3cr.)	X										X				AREN 1027
EGG 140 Engineering Projects (3cr.)					X										GEEN 1400
EGG 206 Mechanics of Solids (3cr.)					X										MCEN 2063 OR CVEN 3161
EGG 211 Engineering Mechanics I -Statics (3cr.)	X				X	X					X		X		MCEN 2023 OR CVEN 2121
EGG 212 Engineering Mechanics II -Dynamics (3cr.)	X				X	X					X		X		MCEN 2043 OR CVEN 3111
EGG 230 Thermodynamics (3cr.)					X										MCEN 3012 OR AREN 2110
EGG 271 Theoretical Mechanics-Statics (3cr.)									X		X				MCEN 2023 OR CVEN 2121
EGG 272 Theoretical Mechanics-Dynamics (3cr.)									X						MCEN 2043 OR CVEN 3111
GENERAL EDUCATION COURSES - HUMANITIES/SOCIAL SCIENCES (H/SS) EQUIVALENTS															
ENG 121 English Composition I (3cr.) ENG 122 English Composition II (3cr.)	*NOTE: ENG 121 & 122 only count as a Free Elective in all majors of the College of Engineering and Applied Science. The number of Free Elective credits varies by department, but is generally 1-4 credit hours. Both courses are still strongly considered for better preperation in subsequent coursework and both are required for statewide A.A. and A.S. degrees.*														
All College of Engineering and Applied Science Humanities and Social Science courses should be taken from the approved list. This CCCS equivalent list can be found at: http://www.colorado.edu/engineering/admissions/transfer															
NOTE: CU-Boulder courses accepted by the College of Engineering and Applied Science can also be found at ***www.colorado.edu/engineering/academics/policies/hss***															

ADDITIONAL NOTES:

*Grades of a C- or higher are required to transfer to CU-Boulder. However, individual departments may have higher grade requirements for select courses. Please consult with an academic advisor in your intended transfer program to be aware of all policies and transfer credit details.

*Table prepared February 2014 and shows Colorado Community College courses that may be applied to specific majors for matriculants into CU-Boulder College of Engineering and Applied Science during the 2014-2015 academic year.

Appendix D. Sample (original) transfer guide, January 2017.

Updated 01/2017

CCD to CU-Boulder Transfer Advising Guide for Aerospace Engineering (B.S.)

College of Engineering and Applied Science

Aerospace Engineering Sciences Department Website

Program Overview:

CU-Boulder's Department of Aerospace Engineering Sciences is nationally known for teaching, research and hands-on experiments and design projects alongside expert faculty. CU aerospace alumni are working at top companies and research labs, including the Jet Propulsion Laboratory, Johnson Space Center, Boeing, and Lockheed Martin. Our graduates tackle challenges in aerospace technology and science, focusing on Aerospace Engineering Systems, Astrodynamics & Satellite Navigation Systems, Bioastronautics and Remote Sensing, Earth & Space Sciences.

Admission Requirements:

Please see this website for more information regarding CU Engineering admission criteria

CCD Course Summary: (the following courses will apply directly to the degree)
*__BOLD__ *denotes admission requirement courses*
**denotes recommended requirement before transferring*

Mathematics:

MAT 201*	**Calculus 1**	**(5 credits)**
MAT 202*	**Calculus 2**	**(5 credits)**
MAT 204	Calculus 3	(5 credits)
MAT 261+MAT 255	Differential Equations + Linear Algebra	(7 credits combined)
OR MAT 266	Differential Equations/Linear Algebra	(4 credits)

Science:

PHY 211*	**Calc-based Physics 1**	**(5 credits)**
PHY 212*	**Calc-based Physics 2**	**(5 credits)**
CHE 111	General Chemistry 1	(5 credits)

CHE 111 will also count for admission requirement in place of PHY 212

Engineering/Computer Science:

CSC 160**	**Computer Science 1**	**(4 credits)**

Humanities and Social Sciences (H/SS):

- Up to fifteen (15) credit hours at the lower division (100-200) level
  - *(ENG 111 and 112 are NOT required and NOT counted as H/SS Electives)*
- Six (6) credit hours the upper-division level – *typically taken at CU-Boulder*
- Please consult our CCCS humanities and social science list when selecting these classes

Updated 01/2017

Suggested Five-Year Course Plan for Aerospace Engineering

This is a suggested guide of coursework only and is subject to change. Always consult with your academic advisor for graduation planning purposes.

*denotes courses that do not apply directly to degree, other than as free electives

Community College of Denver (first two years)

Fall Semester 1

Course	Course Title	Credits
MAT 121	College Algebra*	4
ENG 121	English Composition*	3
	Free Elective*	3
	Total Credits	**12**

Spring Semester 1

Course	Course Title	Credits
MAT 166	Pre-Calculus*	5
CHE 101	Intro to Chemistry (with Lab)*	5
	Humanities/Social Science	3
	Humanities/Social Science	3
	Total Credits	**16**

Fall Semester 2

Course	Course Title	Credits
MAT 201	Calculus 1	5
CHE 111	College Chemistry (with lab)	5
CSC 160	Computer Science 1	4
	Total Credits	**14**

Spring Semester 2

Course	Course Title	Credits
MAT 202	Calculus 2	5
PHY 211	Physics 1	5
	Humanities/Social Science	3
	Total Credits	**13**

CU-Boulder (last three years)

Fall Semester 3

Course	Course Title	Credits
APPM 2350	Calculus 3	4
ASEN 2001	Statics, Structures and Matls.	4
ASEN 2002	Thermo and Aerodynamics	4
ASEN 2012	Exp. & Comp. Methods	2
	Total Credits	**14**

Spring Semester 3

Course	Course Title	Credits
APPM 2360	Differential Eq./Lin. Algebra	4
ASEN 1022	Materials Science for Aero.	4
ASEN 2003	Intro to Dynamics and Syst.	5
ASEN 2004	Vehicle Design and Perform.	5
	Total Credits	**18**

CU-Boulder (last three years)...continued

Fall Semester 4

Course	Course Title	Credits
ASEN 3111	Aerodynamics	4
ASEN 3112	Structures	4
ASEN 3113	Themo and Heat Transfer	4
PHYS 1120	Physics 2	4
	Total Credits	**15**

Spring Semester 4

Course	Course Title	Credits
ASEN 3128	Aircraft Dynamics	4
ASEN 3200	Orbit Mech. /Attitude Dyn.	4
ASEN 3300	Electronics and Comms.	4
	Professional Area Elective	3
	Total Credits	**15**

Fall Semester 5

Course	Course Title	Credits
ASEN 4013	Found. of Propulsion	3
ASEN 4018	Senior Projects	4
	Professional Area Elec. (x2)	6
	Engineering Writing Course	3
	Total Credits	**17**

Spring Semester 5

Course	Course Title	Credits
ASEN 4028	Senior Projects 2	4
	Professional Area Elec. (x2)	6
	UD Humanities/Social Science	3
	UD Humanities/Social Science	3
	Total Credits	**15**