Reimagining an Integrated Pathway to Engineering Careers

Findings and Recommendations From the Fresno K-16 Collaborative

AT A GLANCE

The Fresno K-16 Collaborative is a signature initiative of the California Governor's Council on Post-Secondary Education that aims to increase college degree attainment in high-demand industries, align educational preparation with the demands of regional employers, and close race and equity gaps by developing an integrated system and seamless set of educational experiences across the region's K-12 districts, community colleges, and four-year universities.

This report describes the process of participatory design and asset mapping facilitated by JFF from July 2021 to March 2022; lays out a set of recommendations for deepening, scaling, and sustaining the progress that has been made by the engineering pathway during the pilot period; and offers lessons for other stakeholders interested in launching K-16 regional collaboratives.

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About JFF

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Executive Summary

The Fresno K-16 Collaborative is a signature initiative of the California Governor's Council on Post-Secondary Education that aims to increase college degree attainment in high-demand industries, align educational preparation with the needs of regional employers, and close race and equity gaps by developing an integrated system and seamless set of educational experiences across the region's K-12 districts, community colleges, and four-year universities. During the initial pilot period (July 1, 2020, to March 31, 2022), regional education leaders received state funding to advance four priority industry pathways, including engineering.

Engineering degrees offer tremendous potential for Fresno-area students to enter well-paying careers in high-growth fields. Still, the region produces too few graduates in engineering-related disciplines, and women and students of color remain underrepresented in degree programs.[1]

To support the engineering pathway, JFF was charged with engaging leaders in developing a first-of-its-kind prototype for horizontal integration across four K-12 districts, three community colleges, and the engineering schools at Fresno State University and the University of California, Merced (UC Merced). The overarching question driving this engagement was: *What would it look like for partner institutions to operate as a fully integrated K-16 engineering pathway designed to meet the K-16 Collaborative's goal of increased bachelor's degree completion?*

An important grounding activity for the pathway partners was to articulate their shared vision for success. Using an iterative, co-creation process, the partners identified the following Engineering Pathway Shared Vision Statement:

> *Students in the Fresno region—particularly those from groups underrepresented in engineering fields—have the engagement, role modeling, support systems, financial resources, math instruction, and work-based learning experiences to meet critical milestones from K-12 through bachelor's degree completion and see that engineering is for people of all backgrounds. This set of co-curricular supports is co-designed by K-12, community college, and university partners, with shared responsibility for key pathway assets, addressing institutional barriers, and increasing student achievement.*

Through a student journey mapping exercise and asset mapping process, JFF and the Engineering Pathway leaders identified critical milestones for student achievement and surfaced a wide range of existing resources supporting student success. The analysis found, however, that many of these resources remain siloed and that the partner institutions need to develop new

ways of working together to address shared needs. Additionally, leaders expressed a need to identify shared targets, baselines, and consistent processes for data-driven planning.

At the conclusion of the participatory design process, JFF distilled findings and developed a set of recommendations for moving beyond isolated efforts toward an integrated, co-designed, and co-owned K-16 engineering pathway.

Select findings and recommendations for pathway design include but are not limited to:

Teaching and Learning

Enhancing K-12 math preparation is critical to expanding access to engineering. Engineering Pathway partners emphasized that fundamental math skills are a gatekeeper, with the ability to either unlock opportunity or serve as a barrier for future readiness for dual enrollment in college math courses, as well as calculus and beyond.

- **Recommendation:** Identify successful models that can be scaled to enhance K-12 STEM curricula and align course content with college math requirements and key student journey milestones.

Academic and Student Support

Supporting students of color and female students requires population-specific outreach and program design that address systemic inequities.

- **Recommendation**: Design intentional outreach, support, and cohort programs for specific student populations at all phases of the student journey.

Tutoring resources are currently underutilized and may be seen as inaccessible.

- **Recommendation:** Develop and pilot an embedded tutoring model for high school math courses to provide accessible support within students' everyday learning environments.

Industry Alignment

A regional employer engagement strategy is needed to intentionally integrate work-based learning.

- **Recommendations:** Develop a clear continuum of work-based learning opportunities; identify an organization or team that will play a workforce intermediary function to coordinate requests of the region's employers and produce a clear menu of engagement opportunities.

Ensure engineering pathway fields are aligned to labor market needs and provide students with opportunities for living-wage jobs.

- **Recommendation**: Convene industry advisory boards and develop a process for regularly incorporating labor market information into pathway planning.

Select findings and recommendations for Engineering Pathway leadership and decision-making include but are not limited to:

Goals and Targets

Collaborative partners need shared long-term goals and consistent definitions to enable data-informed decision-making.

- **Recommendations:** Adopt a shared goal for increasing engineering degree completion in the Fresno region by 2035; identify quantifiable targets; establish a baseline; adopt a shared methodology for monitoring participation and outcomes.

Governance and Communication

Gaps in information and resource sharing constrain partnership-building efforts.

- **Recommendations:** Building on the governance structure developed by the Fresno K-16 Collaborative, establish clear roles, responsibilities, and accountability mechanisms for sustained work of the K-16 Engineering Pathway; develop a shared set of communication strategies, practices, and engagement principles.

Funding

Building and sustaining an integrated system requires dedicated capacity and funding.

- **Recommendations**: Allocate funds to support dedicated release time for key institutional leaders to advance K-16 engineering pathway work; identify opportunities to braid funding by leveraging multiple state and system-level initiatives with aligned goals.

As the Fresno K-16 Collaborative pilot period concludes, the Engineering Pathway has developed a strong foundation and charted a clear path forward. As has been evident throughout this process, horizontal integration across educational segments—each of which was created to respond to its own sets of stakeholders, policies, and incentives—presents unique opportunities and challenges, and requires entirely new ways of working, thinking, and interacting. As they continue to advance a shared action plan, the experience of the Fresno K-16 Engineering Pathway leaders will continue to be instructive for other regional leaders across California and nationwide.

About the Fresno K-16 Collaborative

The Fresno K-16 Collaborative is a signature initiative of the Governor's Council on Post-Secondary Education that aims to increase college degree attainment in high-demand industries, align educational preparation with the demands of regional employers, and close race and equity gaps by developing an integrated system and seamless set of educational experiences across the region's K-12 districts, community colleges, and four-year universities. Core educational partners in the K-16 Collaborative include but are not limited to:

Four-year universities:
Fresno State University and the University of California, Merced

Community colleges:
Clovis College, Fresno City College, and Reedley College

K-12 school districts:
Central Unified, Clovis Unified, Fresno Unified, and Sanger Unified

The K-16 Collaborative was developed as a response to rapidly changing workforce needs and an imperative to better prepare the region's student for opportunities that lead to careers in high-growth industries. To meet a new set of employer demands, close persistent equity gaps, and provide the necessary guidance and direction for students from kindergarten through postsecondary graduation, working in silos across K-12 and higher education is no longer an option. The Fresno K-16 Collaborative and associated state funding seek to address this challenge.

The intersegmental educational partnerships in the Fresno K-16 Collaborative trace their origin to the Fresno Regional College Pipeline initiative, convened in 2018 by the Central Valley Community Foundation. While the original charge of the group was to develop a shared strategy for doubling the region's bachelor's degree attainment by 2030, the leaders recognized that their work had a larger equity imperative and transformative potential for their community. The group coalesced around a more ambitious vision of "creating an equitable system that empowers all students to achieve social and economic well-being" and identified priorities including high school completion and college readiness, postsecondary success, and closing achievement gaps.

The accomplishments of the Fresno Region College Pipeline helped lay the foundation for key initiatives in the Fresno DRIVE (Developing the Region's Inclusive and Vibrant Economy) Community Investment Plan. The DRIVE plan was developed in 2019 with input from a 300-person steering committee representing more than 150 organizations in the Greater Fresno

region. The composition and scope of DRIVE is unprecedented, representing a diverse group of civic, community, and business leaders that collectively sought to answer the question: *What would it take to fundamentally transform the Greater Fresno region by 2030 and create opportunities for all residents to achieve real economic mobility by fostering an economy that is inclusive, vibrant, and sustainable?*[2]

The Fresno K-16 Collaborative represents one of the core human capital initiatives in the DRIVE plan. Collectively, the Fresno K-16 Collaborative aims to:

1. Better align secondary and postsecondary programs and increase postsecondary capacity.
2. Reduce achievement gaps by furthering student success for all students, regardless of race, gender, age, disability, or economic circumstances.
3. Create a multigenerational culture of educational attainment by focusing on strategies to improve students' successful completion of degree and certification programs, increasing students' future earning potential and ending the cycle of poverty that many students, and subsequently their children, may experience.

Leaders prioritized four key industry pathways to develop in the first phase of public investment: engineering, accounting and financial management, single-subject teaching, and upskilling for dual enrollment teachers.

The Governor's Council on Postsecondary Education dedicated $10 million of funding from the California Office of Planning and Research for a two-year pilot to advance these four pathways and build on the existing work happening across the Fresno region. The period of performance for these initial pilot funds was July 1, 2020, to March 31, 2022, with a total of 22 funded projects across the participating institutions. Projects incorporated a set of nine design principles and nine key elements, including a focus on dual enrollment as a central strategy for closing race and equity gaps.

About the Fresno K-16 Engineering Pathway

Representing one of the four focal industries selected by the Fresno K-16 Collaborative for the initial pilot period, the Engineering Pathway aims to build an integrated, replicable, and regional strategy to increase degree completion for populations historically excluded from STEM, close equity gaps, and expand access to living-wage jobs.

The K-16 Engineering Pathway includes all school districts, community colleges, and four-year universities participating in the Fresno K-16 Collaborative, though only a smaller subset of institutions received dedicated funding for engineering-related projects. The K-16 Engineering Pathway is co-sponsored by Jerry Buckley, president of Reedley College, and Saul Jimenez-Sandoval, president of Fresno State. Karri Hammerstrom serves as the dedicated executive director of the Fresno K-16 Collaborative administrative team, overseeing the work of all four pathways.

Since its inception, a focus on regional collaboration has been at the center of the Engineering Pathway objectives. As articulated by Reedley College in its original project proposal,

> **"Only by working regionally will we be able to scale our efforts to address the existing and projected deficit of trained local professionals ready to enter … engineering fields [and engineering-related disciplines]."**

Targets and Gaps

Postsecondary leaders identified the following target outcomes for the initial two-year pilot:

Engineering Pathway Targets for Pilot Period

K-12 school districts were charged with increasing college readiness and enhancing STEM preparation in order to support the region in meeting these ambitious targets.

Institutions seeking Fresno K-16 Collaborative Engineering Pathway funding were given the flexibility to propose their own projects aligned with these targets. Across the five institutions that were awarded funding for engineering-specific projects—Central, Fresno, and Sanger Unified school districts; Reedley College; and Fresno State—the partners identified a total of 498 students served.

Recognizing the need for a closer look at baseline participation rates by race and ethnicity, Reedley College leaders engaged their institutional research department in analyzing fall 2019 student participation data for Associate of Science degree programs in engineering fields across three State Center Community College District institutions (Clovis College, Fresno City College, and Reedley College). The data revealed the following equity gaps:

- **Consistent underrepresentation of female students and Black students in engineering programs at all three community colleges**
- **Underrepresentation of Asian and Pacific Islander students in engineering programs at Reedley College**
- **Underrepresentation of Latinx students at Fresno City and Clovis Colleges**

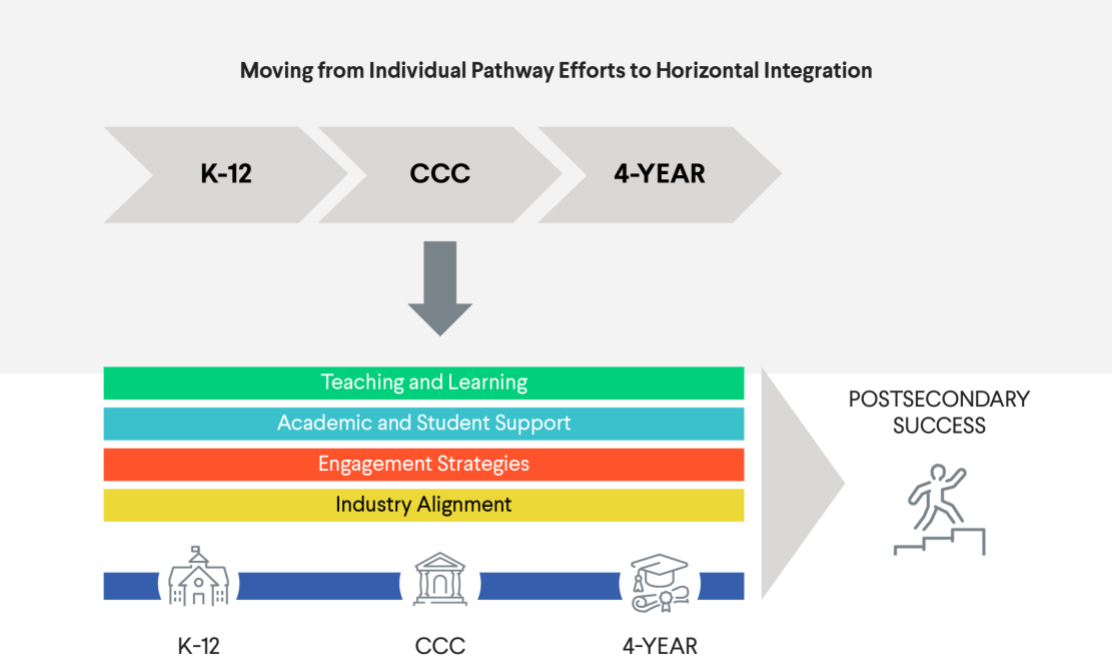
The Engineering Pathway institutions recognize a shared imperative to address persistent problems of race and gender disparities in engineering fields, starting from early STEM

preparation in grades K-12 and reaching all the way to transfer, bachelor's degrees, and career outcomes.

Project Charge and Objectives

To support the goals of the Fresno K-16 Engineering Pathway, as demonstrated in Figure 1, JFF was charged with engaging leaders in developing a first-of-its-kind prototype for horizontal integration: co-designing a common approach and shared resources across a core set of functions (e.g., teaching and learning, academic, and student supports) spanning K-12 institutions through community colleges, transfer, and bachelor's degree completion. Throughout the project, JFF applied the principle of dual transformation—a strategy that holds space for the short-term changes needed to bridge disconnects and improve outcomes across existing systems as well as the longer-term work of reimagining new systems that have the potential for transformative change.

Figure 1: Engineering Pathway Horizontal Integration Prototype



In the development of this prototype, JFF mapped current assets and resources within each of the partner institutions with the goal of developing a strategy for alignment. Through the engagement of intersegmental stakeholders in collaborative design sessions, JFF focused on unpacking the barriers that contribute to equity gaps in degree completion of engineering programs and exploring shared solutions.

At the conclusion of the project, JFF was asked to produce a report on the process, findings, and recommendations for the Engineering Pathway's prototype. This report is intended to model an approach to intersegmental planning and program delivery that can be shared and replicated across the other pathways in the Fresno K-16 Collaborative as well as the growing set of regional K-16 education collaboratives across the state.

Project Approach

Design Principles

The Fresno K-16 Collaborative identified a set of design principles that cut across the four focal industry pathways.[3] In consultation with Engineering Pathway leadership, JFF homed in on the following key principles to guide the approach to collaboration and co-design of a fully integrated K-16 system. These principles provide a lens for interpretation and analysis of the findings and recommendations emerging from this project.

Demonstrate significant strides to close the equity gap

Equity-centered design recognizes that our education, workforce, and economic systems have historically reproduced inequality—but antiracism and attention to the needs of special populations can be built into the design process from the start, rather than as an afterthought. Through critical inquiry, leaders and practitioners can unpack the factors that lead to unequal outcomes and build race-conscious and population-specific solutions.

Eliminate institutional and transitional barriers in the delivery of K-16 education

To create a more seamless pipeline from early education through bachelor's degree completion and career success, leaders can begin by mapping the ideal student journey, articulating critical milestones, and identifying existing assets that can be leveraged to support success at each milestone. Asset-based design emphasizes uplifting and building on the existing resources and prior achievements of institutions and communities, rather than emphasizing negative outcomes or deficits. JFF's approach to mapping resources and developing recommendations started with understanding the foundation that has been built by the Fresno K-16 Collaborative administrative team and institutional partners throughout the pilot period.

Be student-centered, ensuring success for all students throughout K-16 and addressing pain points and barriers for the most vulnerable population(s)

Building a strategy that is responsive to the needs of target populations requires inclusion in process and outcomes. Too often, strategy is designed, and resources are allocated by groups with high levels of power and privilege, without involvement of the students, families, faculty, and employees most affected by these decisions. Authentically engaging student voice and

prioritizing input from historically excluded groups in design, decision-making, and implementation leads to greater innovation and more responsive solutions.

Be a bold K-16 intersegmental collaboration

Creating a fully integrated K-16 engineering pathway with partners across education segments (e.g., K-12 districts, California community colleges, and the California State University and University of California systems) will require a new type of collaboration that transcends jurisdictional boundaries and transactional partnerships. In our approach to facilitation, JFF incorporates systems change principles and key leadership characteristics that are essential for building and sustaining intersegmental collaboration.

Develop a program process that is replicable in regions facing similar problems

Like any region, the Fresno region is characterized by specific place-based conditions that shape educational systems and outcomes. At the same time, the Fresno K-16 Engineering Pathway offers important learnings that can be extrapolated and contextualized to other pathways and regions. With a view toward surfacing replicable learnings that would benefit future programs and collaboratives, JFF has provided a set of recommendations and considerations for other K-16 collaboratives.

Guiding Questions

These guiding questions, which emphasize equity, inclusion, and dual transformation, helped shape the engagement approach and processes throughout the project:

- What would it look like for partner institutions to operate as a fully integrated K-16 engineering pathway designed to meet the K-16 Collaborative's goals of increased bachelor's degree completion? What does the collaboration need to look like to support a cohesive student journey from early STEM preparation and college readiness to living-wage jobs in STEM fields?
- What are the key student milestones in the engineering pathway at each level of education?
- What are the barriers that contribute to equity gaps at key student milestones in engineering pathways, and what would it look like to design intersegmental solutions to address these barriers?
- What assets and resources are currently available across the Fresno K-16 Engineering Pathway?
- What are the key opportunities to share intersegmental assets and resources across school districts, colleges, and universities?

Project Methodology

Working closely with Engineering Pathway leaders and members of the K-16 Collaborative, JFF established a comprehensive work plan over six months that guided the horizontal integration needed to design a student-centered engineering pathway. Leveraging the work already in progress, including existing working groups and guided pathway meetings with institutional leaders, JFF met with Engineering Pathway leaders to gather baseline materials and understand the existing infrastructure in place.

In the data collection phase, JFF applied a mixed-methods research approach to integrate both qualitative and quantitative data. Quantitative data sources included baseline data and targets for the engineering pathway; qualitative data sources included individual institutions' pilot project proposals, Fresno K-16 Collaborative progress reports, and input provided by K-16 Engineering Pathway partners through a series of participatory design sessions and activities. Additional consultations with K-16 Engineering Pathway partners were embedded throughout the process to vet and validate the key findings, recommendations, and action plan. This mixed-methods approach was coupled with principles of equity-minded inquiry and action research cycles.

Participatory Design Sessions

Throughout the project lifecycle, JFF facilitated two types of participatory design sessions—full-group collaborative design sessions and smaller "role-alike" group sessions—with distinct yet interrelated objectives. These participatory design sessions took place across the following three phases, from July 2021 through January 2022 (see Figure 2 below):

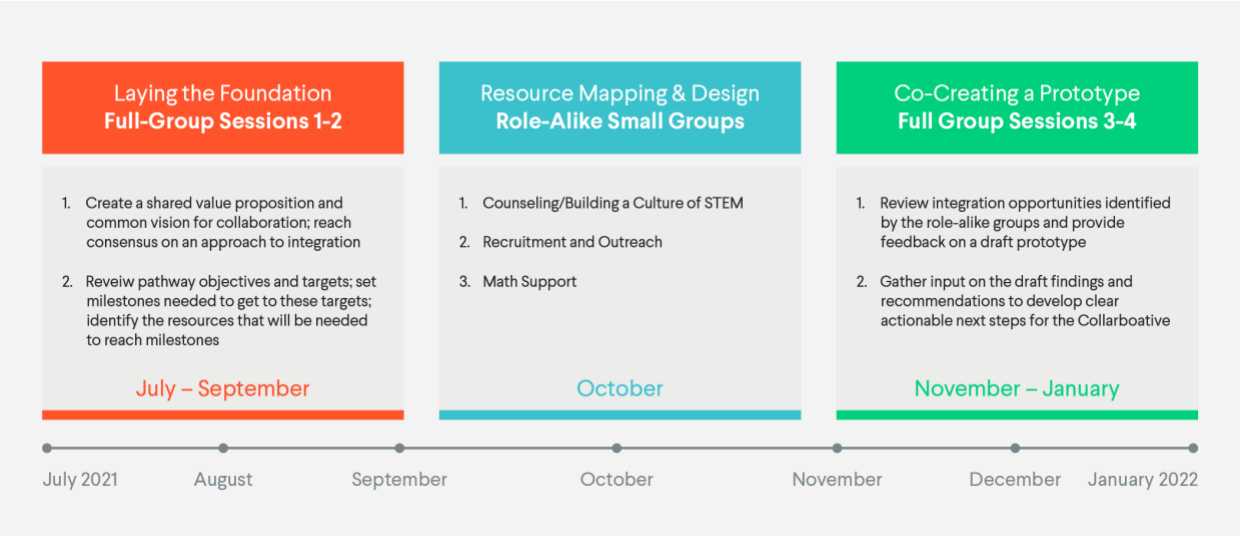
1. Full-Group Collaborative Design Sessions:

JFF hosted four collaborative design sessions with K-16 Engineering Pathway representatives across the institutions. The objectives of these design sessions are detailed in Figure 2.

2. Role-Alike Group Sessions:

To complement the collaborative design sessions, JFF facilitated three focused role-alike small group meetings to gather in-depth data from the key employees at partner institutes who interact regularly with students. The purpose of the role-alike groups was to map the resources that exist in the regional ecosystem to support current and future engineering students, identify gaps, and assess opportunities for alignment. As shown in Figure 2, the role-alike groups were focused on three topics: recruitment and outreach, math support, and counseling/building a culture of STEM. Participants consisted of stakeholders of various roles, such as math professors, counseling leads, and district leaders.

Figure 2: Learning Arc for the Participatory Design Process



Products From Participatory Design Sessions

Through the participatory design process, the Engineering Pathway members produced three co-created products: 1) the Engineering Pathway Shared Vision Statement, 2) the Student Journey Map, and 3) the Asset and Resource Mapping.

Engineering Pathway Shared Vision Statement

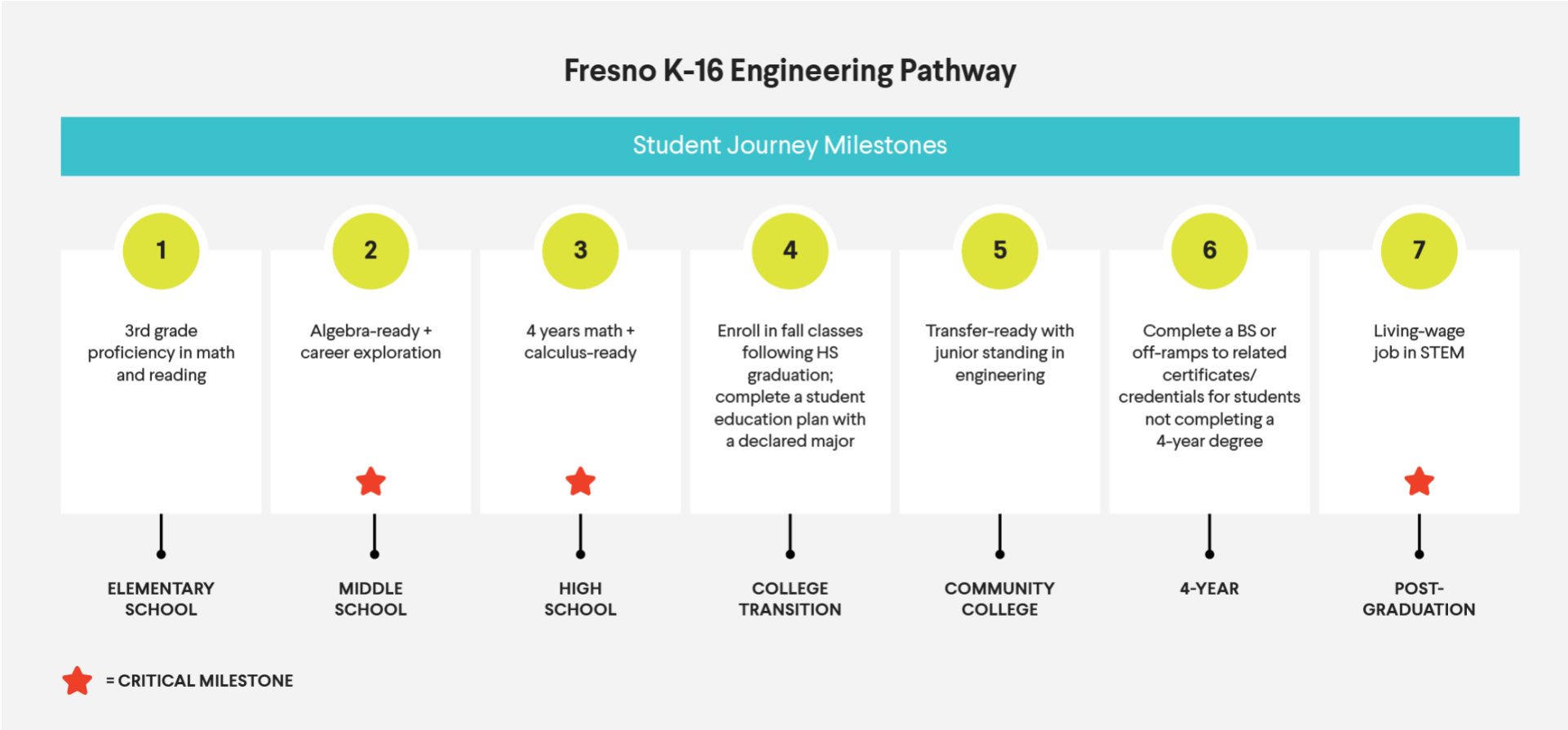
The Engineering Pathway Shared Vision Statement aims to set an aspirational vision not only for student outcomes within the engineering pathway, but also for a new, fully integrated way of working across institutions.. Through an iterative co-creation process, the Engineering Pathway group members adopted the following shared vision statement:

> ***Engineering Pathway Shared Vision Statement***
> *Students in the Fresno region—particularly those from groups underrepresented in engineering fields—have the engagement, role modeling, support systems, financial resources, math instruction, and work-based learning experiences to meet critical milestones from K-12 through bachelor's degree completion and see that engineering is for people of all backgrounds. This set of co-curricular supports is co-designed by K-12, community college, and university partners, with shared responsibility for key pathway assets, addressing institutional barriers, and increasing student achievement.*

Student Journey Map

Within the first two collaborative design sessions, the Fresno K-16 Engineering Pathway partners developed a student journey map, reaching consensus on a set of seven key milestones that needed to be reached at each phase of the educational pipeline, from elementary school to bachelor's degree completion and beyond, to successfully prepare students for engineering careers *(*see Figure 3 below*)*. The journey mapping exercise required leaders to look beyond their institutional boundaries and priorities by focusing on the student experience; this co-designed product can be used as a set of guideposts for aligning individual efforts to shared long-term objectives. The student journey map also provides a framework for identifying and mapping the resources and support students need for success at each milestone.

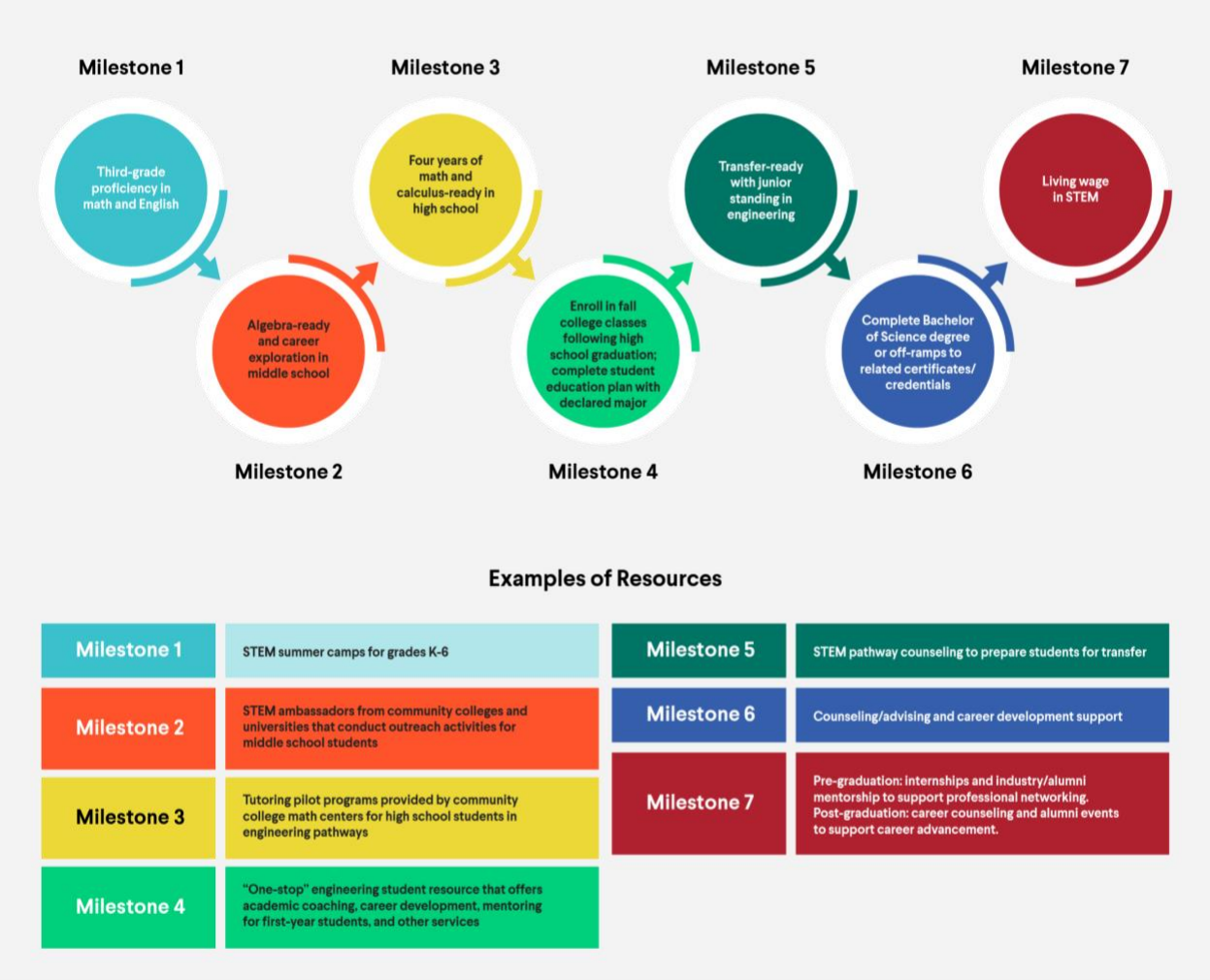
Figure 3: Student Journey Map and Milestones



Asset Mapping

As part of an asset-based design strategy, JFF facilitated an asset mapping exercise that asked K-16 Engineering Pathway partners to document resources within their individual institutions that support students across the critical student journey milestones. The asset mapping exercise, which took place over the three role-alike sessions, offered an opportunity to identify the programs, people, services, and other resources that already exist and could be leveraged as shared regional resources for the pathway. Figure 4 provides a snapshot of the types of resources named by the K-16 engineering pathway partners across each of the student journey milestones.

Figure 4: Illustrative Examples of Assets Aligned with Student Journey Milestones



The goal of this exercise was to help the Engineering Pathway partners better assess where there is an abundance of assets and where there is a need for additional resources to support current and future engineering students across the student journey.

Areas of abundance included:

- A variety of tutoring and advising services available to support students in STEM courses across the student journey.
- A high concentration of resources and services focused on supporting the transition to college (milestone 4).
- A recognition that older students can serve as an important shared asset, with capacity to tutor and mentor younger students in the engineering pathway.
- A positive funding outlook given recent stimulus investments and a strong state budget climate. This resource-rich environment reflects the state investments in the Fresno K-16 Collaborative as well as federal stimulus funds and a robust state budget climate.

Gaps identified included:

- An unequal distribution of resources and services along the student journey, with few dedicated resources for milestones 1 (third-grade-level proficiency in math and reading) and milestone 6 (complete a Bachelor of Science degree or off-ramps to related certificates/credentials for students not completing a four-year degree).
- An ongoing need for more intentional outreach and program design focused on target populations within the engineering pathway, such as female students and students of color, to align with the Fresno K-16 Collaborative's commitment to closing equity gaps.
- A need for more resources focused on industry alignment, work-based learning, and community-based partnerships.

The analysis of abundant resources and notable gaps across the student journey milestones provided important context for identifying the key findings and recommendations in the final sections of this report. First, however, we focus on a critical theme that emerged from the participatory design process regarding the need for shared goals and targets to help direct and sustain future collaborative work across Engineering Pathway partner institutions.

Key Findings

The findings outlined in this section are centered around the primary guiding question: *What would it look like for partner institutions to operate as a fully integrated K-16 engineering pathway designed to meet the K-16 Collaborative's goals of increased bachelor's degree completion?*

As the asset mapping illustrates, institutions have leveraged the opportunities provided by the Fresno K-16 Collaborative funding and the assistance of the Fresno K-16 Collaborative administrative team to implement an array of assets that support student success across most of the student journey milestones. However, many of these resources remain siloed, and best practices need to be scaled to close equity gaps across the region.

To chart a path forward in service of the Shared Vision Statement, the findings are organized into five categories: 1) Teaching and Learning, 2) Academic and Student Support, 3) Engagement Strategies, 4) Industry Alignment, and 5) Collaboration Infrastructure. These distinct yet interrelated categories collectively make up the building blocks needed to move beyond one-off efforts toward an integrated, co-designed, and co-owned K-16 engineering pathway.

1 Teaching and Learning

Enhancing K-12 math preparation is critical to expanding access to engineering.

K-16 Engineering Pathway partners agreed that the first two student journey milestones—third-grade proficiency in math and reading (milestone 1) and algebra-ready and career exploration in middle school (milestone 2)—are critical prerequisites for the other milestones. However, there are significant gaps when it comes to the rigor of math instruction and the level of curriculum offered across K-12 schools. Engineering Pathway partners emphasized that fundamental math skills are a "gatekeeper," with the ability to either unlock opportunity or serve as a barrier for future readiness for calculus (milestone 3) and beyond. Historic racial and gender disparities in higher-level math courses have been well documented, and Engineering Pathway participants also expressed concerns about inequities in math offerings across schools within the same districts. Some members cautioned that many of the region's high school students are not currently prepared to succeed in college math courses through dual enrollment, due to gaps in their math preparation.

All educational segments need to work collaboratively to ensure math curricula is aligned across the pathway and provides students with foundational math skills needed, ranging from algebra to calculus. Collaborative partnerships to enhance math readiness are underway across some of the partner institutions. For instance, Fresno City College's dean of Educational Services and Pathway Effectiveness has worked closely with each participating K-12 district to address curricular alignment during the pilot period. Lyles College of Engineering at Fresno State has provided early STEM learning experiences, such as a virtual summer camp for grades K-8 and Young Minds Explore Engineering workshops. As another example, Reedley College, Sanger Unified, and the Valley Regional Occupational Program developed the Robotics Is for Everyone series and competitions during the 2021-2022 academic year.

STEM teachers need enhanced professional development.
During role-alike sessions, K-16 Engineering Pathway partners noted that elementary school teachers typically do not have a formal STEM background, and even middle and high school teachers need support to stay up to date on trends in STEM education. Further, STEM teachers have often received limited training on how to tailor and contextualize their pedagogical approaches for diverse student populations.

In addition, K-16 Engineering Pathway partners surfaced concerns about gaps in current academic evaluations and assessments, particularly in K-12 institutions. Current math assessment practices may exacerbate inequity, and differences in grades and test score often correlate to resource disparities rather than being true reflections of student learning. K-16 Engineering Pathway partners expressed the need to move toward assessment strategies that are free of cultural biases and authentically evaluate mastery of math skills. Reedley College, among other regional partners, has begun to set the groundwork to re-envision academic assessment strategies through the Grading for Equity initiative.

Several of the K-16 Engineering Pathway institutions have invested in supporting ongoing professional development of STEM teachers during the pilot period. For instance, Sanger Unified has expanded Project Lead the Way, engineering professional development for teachers of grades three through five. UC Merced's Computer Science for All (CS4All) program focuses on building middle and high school teachers' skills in teaching computer science. Additionally, many institutions have taken the opportunity to implement professional development focused on culturally responsive pedagogy and diversity, equity, and inclusion. Fresno City College has convened K-12 and postsecondary educators throughout the region for equity-focused professional learning experiences, with particular attention to supporting young men of color. The K-16 Engineering Pathway leaders can build on the successes of the existing professional development programs and develop a regional approach to equity-focused professional development for STEM educators.

2 Academic and Student Support

Supporting students of color and female students requires population-specific outreach and program design that address systemic inequities.
Engineering Pathway partners aligned on a common understanding of the problem of underrepresentation of students of color, primarily those who are Black and Latinx, and female students in engineering degree programs. Deeply entrenched structural, systemic, and institutional policies and practices play an important role in determining which students have access and exposure to opportunities within the engineering pathways.

Current outreach and recruitment efforts across institutions aim to address these disparities by actively recruiting students from Title I schools that serve a large share of economically disadvantaged families. At the same time, partners agreed that there is a need for more targeted outreach and support for specific populations. One such example is the Femineers club in Sanger Unified that promotes engineering careers for women. At the university level, UC Merced's "¡Valle! Get your start in tech!" program is designed to support students of color and women in engineering through networking, mentoring, access to internships and graduate school, building a sense of belonging, and other soft skills. Drawing on best practices from other pathways in the Fresno K-16 Collaborative, partners also mentioned the single-subject teaching pathway's cohort model—focused on recruiting and supporting students of color interested in education careers—as an example of a race-conscious strategy with a goal of diversifying a career pathway.

Tutoring resources are currently underutilized and may be seen as inaccessible.
The asset mapping highlighted that there was an abundance of valuable tutoring resources available, both online and in person, through existing high school-college partnerships. For example, all three State Center Community College District institutions mobilized their math centers to offer a tutoring pilot for high schools with engineering pathways. These tutoring programs have been scaled to reach all high schools in the Fresno County region, along with other community members through adult education courses. At the same time, K-16 Engineering Pathway partners shared that existing tutoring services serve only a small proportion of eligible high school students. Limited student and family awareness of tutoring services, transportation challenges, difficulty navigating the college campus, and competing priorities outside of class hours are a few of the barriers that stand in the way of a broader group of K-12 students benefiting from tutoring services.

In an effort to explore solutions to these challenges, the K-16 Engineering Pathway partners discussed the potential of embedded tutoring models like the type that has been piloted by some California community colleges. These models bring tutors into math classrooms, thereby erasing access barriers, normalizing the practice of receiving support, and ensuring that instruction provided by tutors is aligned with course curriculum.

3 *Engagement Strategies*

There is a need to engage parents as partners and build awareness of STEM opportunities.
From encouraging initial interest in math from an early age to providing ongoing support throughout the student journey milestones, parents have a transformative role to play in encouraging and supporting their children in STEM. Educating parents around the importance of a STEM education and the significance of upper-level math courses along with approaches to support their children along their learning journey can provide another opportunity to close equity gaps for student groups such as female students and students of color. For this reason, the K-16 Engineering Pathway partners expressed that the education of parents is just as important as the education of students when it comes to developing a regional culture of support for STEM.

Mentorship strategies can be most impactful when students from populations seeking proportionate representation in engineering see themselves reflected.
Engineering Pathway leaders view career awareness, exposure, and experience as important pathway elements to keep students engaged in STEM. In many cases, exposure to professional mentors for students in grades K-12 is limited to guest presentations, such as those from professionals at NASA and local engineering firms, and speakers seldom reflect the demographic diversity of the Fresno region. Engineering Pathway members shared that it was important for students to feel that they are represented by their mentors, tutors, and support network. To believe their aspirations within STEM are attainable, students need to be able to see a reflection of themselves in current college students, professors, and engineering professionals. Representation can take many shapes and forms, and includes common characteristics, such as where students grew up, their socioeconomic backgrounds, gender, race, lived experiences throughout childhood, and shared cultural backgrounds.

4 Industry Alignment

A regional employer engagement strategy is needed to intentionally integrate work-based learning.

K-16 Engineering Pathway partners highlighted that there were limited opportunities to integrate work-based learning at scale across the engineering pathway. Building partnerships with employers and workforce development organizations within and outside of the Fresno region would help catalyze students' exposure to real-life STEM opportunities. This type of relationship-building with external partners requires both intentional outreach and dedicated employee time within institutions.

Some Engineering Pathway partners focused on work-based learning during the pilot period—for instance, Fresno Unified offered virtual internships for engineering students, in partnership with Fresno State and Fresno Pacific Universities, during summer 2021. At the university level, UC Merced offers industry-partnered programs like Engineering Service Learning and engineering capstone work alongside industry partners to create real-world projects for students to work on as part of their engineering coursework. Still, the pathway would benefit from a clearly articulated continuum of work-based learning experiences across the key student journey milestones. JFF's Center for Work-Based Learning and Apprenticeship provides an example of an intentional framework that builds from career exploration (e.g., career fairs) to career exposure (e.g., job shadows), career engagement (e.g., internships) and finally career engagement (e.g., apprenticeships and on-the-job training).[4]

The engineering pathway also needs a regional approach to manage work-based learning and coordinate asks across local employer partners, instead of unintentionally competing across institutions for employers' limited time and bandwidth. The engineering pathway could benefit from a closer partnership with other employer-facing assets in the Fresno region, including Career Nexus. Developed through DRIVE, Career Nexus matches young adults who have successfully completed a career readiness program with employers offering paid internships and other work-based learning opportunities.

Engineering pathway fields need to be aligned to labor market needs and provide students with opportunities for living-wage jobs.

The K-16 Engineering Pathway members shared the need to integrate employer feedback and updated labor market information into the pathway's planning and target development. LMI provides critical data around forecasted industry demands in the regional and state labor market, which can be used to set degree completion targets and adjust program offerings to ensure that graduates are prepared for in-demand jobs. LMI can also be used to

promote economic advancement and close equity gaps, as it provides the opportunity to assess which degrees and certificates lead to the highest paying jobs and demand equitable representation in these programs. By leveraging LMI, partners can ensure that all engineering programs included in the pathway support progress toward student journey milestone 7, a living wage in a STEM job.

5 *Collaboration Infrastructure*

Collaborative partners need shared long-term goals, targets, and definitions to enable data-informed decision-making. A common issue raised across the participatory design sessions was a need for data-driven planning to achieve shared regional goals. While the Engineering Pathway leaders identified an initial set of targets for increasing degree completion and transfer in engineering-related disciplines and closing race and gender equity gaps during the pilot period, partners remained concerned about the lack of a consistent methodology for identifying and tracking engineering pathway students across institutions and segments. This issue can be particularly confusing at the K-12 level, as different districts and schools take different approaches to grouping students into career-themed pathways and many high schools do not offer engineering-specific courses.

Disaggregated data on student participation and success are needed at all stages of the K-16 student journey to identify loss points and equity gaps along the pathway, design data-informed interventions, and evaluate the progress of the group's shared efforts. Moving forward, leaders have the opportunity to establish longer-term degree completion goals that are aligned with labor market demands, identify associated targets at each student journey milestone from elementary school through college, and track progress.

Building and sustaining an integrated system requires dedicated capacity and funding.

Identifying opportunities to leverage shared resources, coordinate closely across segments, and move toward horizontal integration is critical to supporting students across their learning journey. This deep level of coordination and integration needed for intersegmental collaboration is also time-intensive work. However, capacity constraints and competing priorities across institutions serve as barriers to the initiative's sustainability. Leaders from each partner institution shared that they currently do not have the capacity outside of their campus responsibilities to contribute to the shared decision-making and co-design that is needed to build an intersegmental engineering pathway, particularly given the day-to-day emergencies and disruptions they have faced during the COVID-19 era. To sustain the collaborative work, the K-16 Engineering Pathway partners agreed that dedicated resources are needed to fund release time for leaders within each institution. The Fresno K-16

Collaborative also remains committed to providing resources to support the Engineering Pathway.

Gaps in information and resource sharing constrain partnership-building efforts. With the goal of shifting from individual projects and resources toward a horizontally integrated pathway, the Fresno K-16 Engineering Pathway members highlighted the need for more systematized and coordinated resource sharing. The asset mapping exercise illustrated that the K-16 Engineering Pathway partners have access to a diverse set of resources across the student journey milestones; however, there was a low level of awareness across segments of these shared resources.

Awareness gaps reflect a lack of systemic approaches to ensure information regarding shared resources makes it into the hands of the people—students, teachers, administrators, and parents—who would benefit most from it. For example, information about tutoring services and summer camp opportunities is often readily available to school administrators, but it is not consistently communicated to teachers who have the power and proximity to encourage students and their families to avail themselves of these opportunities. Several of the Engineering Pathway members stated that they would benefit from a more comprehensive view of the STEM-focused events and resources offered at each partner institution.

Recommendations

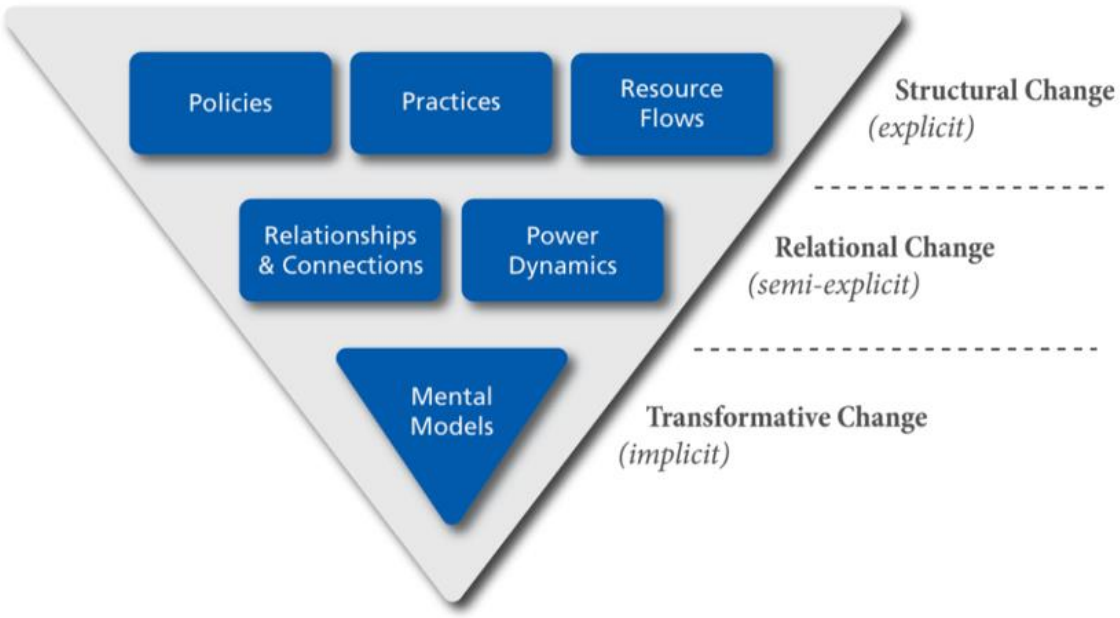
At the conclusion of the participatory design process, JFF developed a set of recommendations for deepening, scaling, and sustaining the progress that has been made by the Engineering Pathway during the initial pilot period. Recommendations were also informed by a review of pathway institutions' project proposals and Fresno K-16 Collaborative progress reports, including the "Structural and Key Components of a Successful Collaborative" that were identified in the December 2021 Progress Report.[5]

This section begins with an overview of the systems change framework that JFF applied to revisit our guiding question: *What would it look like for partner institutions to operate as a fully integrated K-16 engineering pathway?*

Conditions of Systems Change

Developing an integrated K-16 system takes more than increased coordination; reimagining systems requires entirely new ways of working, thinking, and interacting. To illustrate what this looks like in practice, we have drawn lessons from FSG's *The Six Conditions of Systems Change*[6] (Figure 5 below) to provide examples of what it takes to create the enabling conditions, or dismantle deeply entrenched conditions, to build an integrated K-16 engineering system.

Figure 5: The Six Conditions of Systems Change



Source: FSG, 2018.

Figure 6 below provides illustrative examples of what transforming these six conditions may look like in practice for the Fresno K-16 Engineering Pathway.

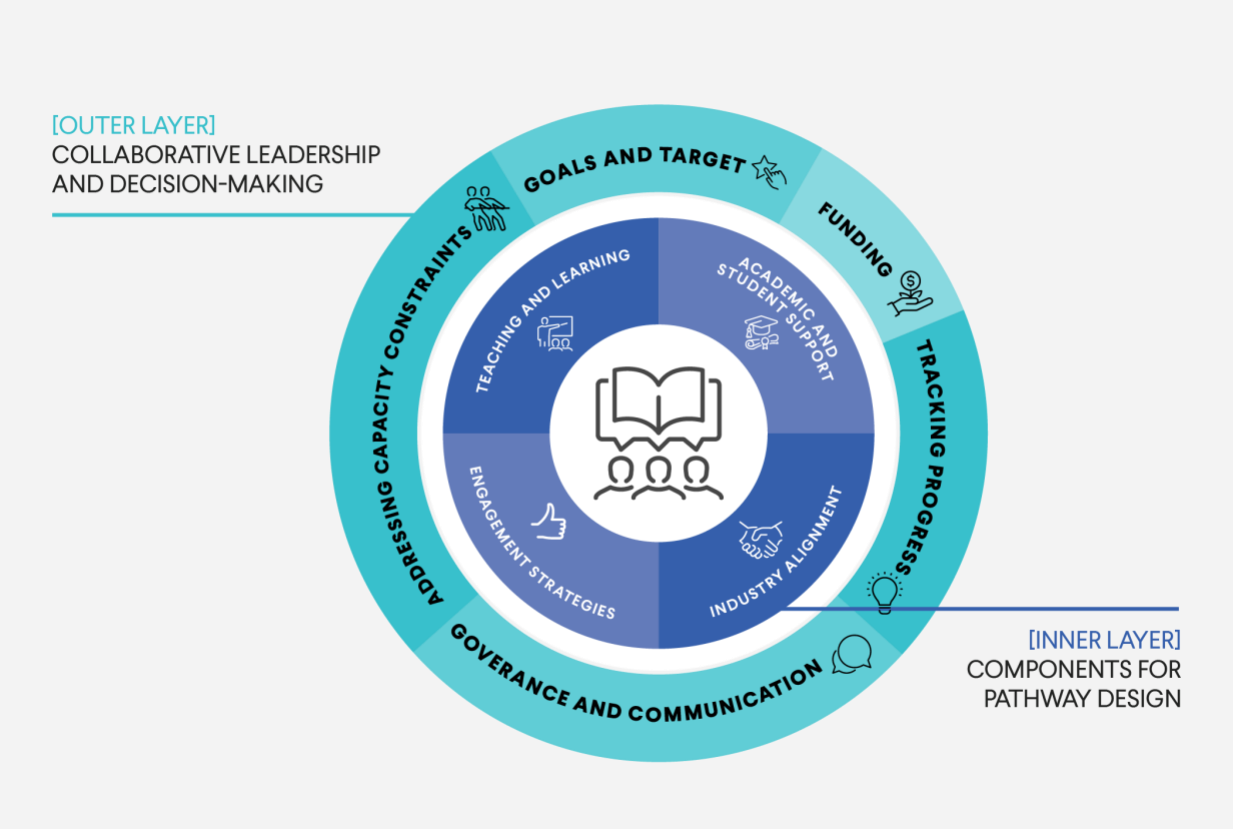
Figure 6: Conditions for Systems Change Applied to Engineering Pathway

Condition for Systems Change	From (Current State)	To (Future State)
Policies	Disconnected strategic plans and institutional initiatives; lack of alignment in state policy incentives or mandates for K-12 districts, CCCs, CSUs, and UCs.	Intentional connections across institutional policies and strategic initiatives; incentives for collaboration between K-12 districts, CCCs, CSUs, and UCs. Increased awareness of the overlapping and mutually reinforcing goals of state policies and investments at each level of the education system.
Practices	Institution-specific programming or partnerships between just two institutions (e.g., a K-12 district and a postsecondary institution).	Shared approach to curricular alignment and co-designing engineering programs and interventions (e.g., tutoring services, mentorship) that are regional in scope.
Resource Flows	Limited resources and capacity for intersegmental planning.	Dedicated resources to support leaders' time across institutions to engage in intersegmental, collaborative planning and implementation, with backfill to manage ongoing institutional responsibilities.
Relationships and Connections	Transactional relationships and information-sharing across institutions; lack of clear roles or decision-making structures for shared work.	A strengthened intersegmental network characterized by trusting relationships, differentiated roles, and clear decision-making responsibilities across institutions.
Power Dynamics	Traditional hierarchies in the field of education privilege the perspectives of colleges and universities and do not fully reflect the concerns and realities of K-12 or employers.	Inclusive practices and shared governance structures that disrupt power dynamics and ensure all institutions and stakeholders are included in solving problems at all levels of the educational pipeline.
Mental Models	A focus on institution-level targets and interventions.	Agreement on shared regional goals for the engineering pathway. Embracing a collective action approach to identify targets, constraints, and solutions for capacity challenges at each critical milestone.

Overview of Recommendations

Recommendations are grouped into two broad categories, as shown in Figure 7 below. Components of the pathway design that directly support students (inner circle) and recommendations for Engineering Pathway leadership and decision-making (outer circle). These two concentric circles collectively make up the key components needed to transition from siloed efforts toward an integrated, co-designed, and co-owned K-16 engineering pathway.

Figure 7: Components for Pathway Design and Engineering Pathway Leadership and Decision-Making



Recommendations for Pathway Design

Recommendations in this category include the changes in practices, relationships, and connections needed to address challenges related to STEM preparation, focus outreach and retention strategies on groups seeking proportionate representation in engineering fields, leverage community assets, and integrate employers as strategic partners.

1. Teaching and Learning

- **Identify successful models that can be scaled to enhance K-12 STEM curriculum and align course content with college math requirements and key student journey milestones**, including an expectation of calculus-readiness by 12th grade (milestone 3). This will require identifying best practices by assessing the effectiveness of local feeder schools' various math programs in preparing graduates to succeed in transfer-level math, as well as a commitment among K-12 and community college leaders to adopt a shared approach that aims to close equity gaps in STEM preparation across the region.

- **Extend access, awareness, and availability of STEM early learning experiences**, such as summer camps, and provide additional wraparound services, such as STEM-focused counseling support, to target the early student journey milestones in K-12. Community organizations, employers, and higher education institutions will be critical partners in this effort.

- **Empower K-12 teachers with the necessary skills, tools, habits, and knowledge to help bridge the gap between academic content and career readiness.** Districts can continue to scale up and expand shared professional development opportunities for teachers, as well as applied and engaging STEM instruction. Districts can develop culturally relevant curricula and employ universal design for learning centered around the needs of student groups without proportionate representation in STEM fields, including Black, Latinx, and female students, and expand professional development focused on "grading for equity."

2. Academic and Student Support

- **Develop and pilot an embedded tutoring model for high school math courses to provide accessible support within students' everyday learning environments**. As a first step, leverage lessons learned from embedded tutoring programs across California community colleges and test various staffing strategies, including hiring undergraduate or graduate students as well as tapping into programs for

aspiring teachers such as the California Teaching Fellows Foundation and the UC Merced CalTeach program. Concurrently, continue to improve the accessibility of college-based math centers for high school students.

- **Design intentional outreach, support, and cohort programs for specific student populations at all phases of the student journey**, including students of color, female students, students with special needs, English learners, students living in remote rural areas, and students who are experiencing homelessness or are in foster care. Partners can build on the identity-based learning communities and resource centers already available at the college level and create intentional strategies to connect with and support underrepresented students pursuing STEM degrees.

3. *Engagement Strategies*

- **Designate roles and responsibilities and build capacity for family outreach and engagement strategies**. Continue to expand the awareness-building efforts and outreach tools that have been developed during the pilot period, such as the Fresno K-16 Collaborative website, with a focus on raising parents' awareness of engineering career opportunities across the important student journey milestones.[7]

- **Identify a core group of external partners and catalysts** that can help to support the Engineering Pathway Shared Vision Statement. This may include community-based organizations, employers and workforce system leaders, families and community members, and other K-16 collaboratives. Develop a shared menu of support needs and opportunities for community engagement, and implement a coordinated approach to securing partner commitments.

4. *Industry Alignment*

- **Develop a clear continuum of work-based learning opportunities** that are integrated across the student journey milestones. These work-based learning opportunities should include a sequence of career exposure, career engagement, and career experience opportunities that build on one another and lead to careers paying a family-supporting wage.

- **Identify an organization or team that will play a workforce intermediary function** to coordinate requests of the region's employers and produce a clear menu of engagement opportunities. The engineering pathway needs to develop operational capacity, labor market awareness, and industry relationships for sustained collaboration rather than one-time engagements.

- **Convene industry advisory boards and develop a process for regularly incorporating labor-market information into pathway planning** at all levels to ensure courses remain relevant to local workforce needs. Leverage the support of the Fresno K-16 Collaborative administrative team to share employer recommendations with all stakeholders, including institutional Academic Senates, and coordinate responses.

- **Develop and deploy a shared cohort of STEM-focused mentors** to provide ongoing career guidance for students. Ensure that the mentorship cohort is reflective and representative of the characteristics of the diverse student population.

Recommendations for Engineering Pathway Leadership and Decision-Making

Recommendations in this category include the changes in policies, resource flows, power dynamics, and mental models needed to incentivize and operationalize ongoing collaboration.

State Policy and Funding Context

While the recommendations in this section are intended to be applicable to the Engineering Pathway partner institutions regardless of the type or structure of future funding that may be available for their combined efforts, there are several current or proposed state and system-level initiatives that could be leveraged to support this work. The 2021 California State Budget Act included $250 million to support additional Regional K-16 Educational Collaboratives, building on the example developed in Fresno. Through this investment, the Fresno K-16 Collaborative has the potential to receive another state-funded grant in spring 2022 to advance its work.[8]

Additionally, the proposed 2022-23 California Governor's Budget includes strong incentives for intersegmental collaboration, with funding for the state's postsecondary education systems tied to partnerships that are intended to raise student outcomes and close equity gaps. More information about these budget proposals and other relevant policies can be found in Appendix C: Crosswalk of Relevant State-Level Initiatives. Leaders are encouraged to identify the connections between the goals and priorities of the Engineering Pathway and the broader set of policy mandates and investments at all levels of the education system, and to leverage a range of funding streams to support their shared regional efforts.

1. Goals and Targets

- **Adopt a shared goal for increasing engineering degree completion in the Fresno region by 2035.** Stakeholders across K-12, higher education, industry, and community partners need a galvanizing goal along with the ability to track progress against key targets.
- **Leverage labor market information data and tools** (e.g., Emsi and Burning Glass Technologies) to ensure that the shared goal is driven by the region's projected need for graduates in engineering-related fields.
- **Disaggregate the overall bachelor's degree completion goal** by race/ethnicity and gender, based on the principle of equitable representation.
- **Identify quantifiable targets** for participation, completion, and equitable representation needed at each student journey milestone to meet the region's shared bachelor's degree completion goal.

2. Addressing Capacity Constraints

- **Assess current institutional capacity and identify resource constraints** that will impact achievement of the shared bachelor's degree completion goal, including human resources (e.g., engineering professors and qualified instructors for STEM courses at all levels) and capital resources (e.g., labs and classrooms).
- **Identify enablers and assets in the ecosystem** that can enhance capacity (e.g., shared facilities and master's degree pathways for current teachers).
- **Develop institution-level goals and targets** based on three key factors: 1) current institutional capacity, 2) leadership commitments to meeting the region's bachelor's degree completion goal, and 3) enablers and assets that can enhance institutional capacity.
- **Develop a shared action plan** to track progress in addressing capacity constraints and continuously evaluate ongoing capacity and funding needs.

3. Progress Tracking

- **Establish a baseline** by adopting a common definition of "students in the intersegmental engineering pathway," with criteria for grades K-8, high school, community colleges, and four-year colleges.
- **Adopt a shared methodology for monitoring participation and outcomes** at each student journey milestone, along with a data dictionary that specifies the data

sources, indicators, and student demographic characteristics to be used beyond collaborative projects.

- **Leverage existing data sharing infrastructure** (e.g., California College Guidance Initiative) and identify roles, responsibilities, and timelines for monitoring intersegmental data.
- **Engage students, families, and faculty and employees in data collection and analysis** to ensure that solutions are responsive to the needs of current and future engineering students.

4. Governance and Communication

- **Building on the governance structure developed by the Fresno K-16 Collaborative**, **establish clear roles, responsibilities, and accountability mechanisms** for sustained work of the K-16 engineering pathway. Distribute leadership and clarify roles for decision-making, implementation, accountability, and consultation across key elements of pathway design. Identify the operations support needed to manage the coordination, planning, and resources to deliver on shared activities and track progress against a shared action plan.
- **Develop a shared set of communication strategies, practices, and engagement principles** for the Engineering Pathway. This could include principles such as effective and frequent communication within the pathway and with students, families, and communities; willingness to listen; appreciation of other leaders' opinions; and recognition of partners' accomplishments.
- **Adopt continuous improvement practices**, such as systematizing the flow of information into the hands of people who need it, using data to inform leadership meetings and engaging in cycles of critical inquiry to better understand the factors that contribute to inequities.

5. Funding

- **Allocate funds to support dedicated release time for key institutional leaders to advance K-16 engineering pathway work.** In order for leaders to prioritize the intersegmental planning required to create an integrated system, they will need backfill support to alleviate their responsibilities at their own institutions. Districts and colleges should consider how they can use state and philanthropic funds to support leaders' release time in the short term to advance a shared action plan based on the recommendations in this report.
- **Identify opportunities to braid funding by leveraging multiple state and system-level initiatives with aligned goals.** Diversifying funding provides the opportunity to move from an engineering pathway defined by a specific grant to a set of

shared, sustained regional priorities. Leaders can refer to the table provided in Appendix C: Crosswalk of Relevant State-Level Initiatives for examples of how the engineering pathway recommendations connect with current and proposed state-level funding opportunities across UC, CSU, community college, and K-12 systems.

Conclusion

Reimagining a new engineering pathway presents an immense opportunity to develop a co-designed and co-owned K-16 system that benefits from shared resources, expertise, and partnership across a broad and diverse region. At the same time, horizontal integration across educational segments—each of which was created to respond to its own sets of stakeholders, policies, and incentives—presents unique challenges and requires entirely new ways of working, thinking, and interacting.

To capture the key learnings from this participatory process of developing an integrated engineering pathway, we have extrapolated the following four recommendations, which can be applied in the design of K-16 Collaboratives in different regions and across other industry pathways:

- **Develop a shared vision statement with critical input from K-16 Collaborative members that will serve as the collective bold ambition** and will help to guide the collaborative's focus areas. Invite collaborative members to co-create the vision statement to reflect shared aspirations for their collective work.
- **Establish a shared set of milestones across a student's K-16 educational journey,** from kindergarten to community college and four-year institutions. Identify the key milestones that will serve as the critical building blocks to students' ultimate success (which, in the case of the engineering pathway, means a living-wage job in a STEM field). Use this student journey map as an anchor throughout the K-16 Collaborative's engagements to help partners look beyond their own institutional boundaries, identify assets, and build awareness of gaps in the ecosystem.
- **Ensure that K-12 leaders are included in the early stages of the design process and build shared strategies for addressing pain points that affect the entire pathway.** Intersegmental collaborations often focus on high school to college transitions and grade 9-14 pathways, without active partnerships focused on grades K-8. However, the Fresno K-16 Engineering Pathway partners identified a solid foundation of math skills as a critical dependency that must be met for success across the rest of the student journey. By shifting their mental model, the leaders have recognized a

need for co-ownership of this challenge and a search for solutions that rely on the combined expertise and resources provided by all institutions in the collaborative.

- **To support sustainability beyond an initial grant, embed the K-16 Collaborative work in each institution's strategic agenda and leverage multiple funding streams with aligned goals.** Start by cross-walking the collaborative's priorities with key initiatives at each level of the education system (see example from the Engineering Pathway in Appendix C) to identify where there are synergies and areas of alignment.

As the Fresno K-16 Collaborative pilot period concludes, the Engineering Pathway has developed a strong foundation and charted a clear path forward. Institutions have launched innovative new programs to address the key elements of pathway design and close equity gaps. Together, leaders have forged a bold vision, achieved consensus on a critical set of milestones, and identified remaining needs. Moving forward, the leaders have the opportunity to strengthen their collaboration infrastructure and advance a shared action plan. Their experience with co-ownership and co-design will continue to be instructive for regional leaders across California and nationwide.

Appendices

Appendix A: Common Definitions and Acronyms

- **Intersegmental collaboration:** An action that requires active partnership and shared decision-making across more than one segment of the California education system (e.g., K-12 institutions, California community colleges, California State University, and the University of California).
- **Horizontal integration:** In the context of this report, refers to co-designing a common approach and shared resources across a core set of functions (e.g., teaching and learning, and academic and student supports) spanning different institutions and levels of the education system.
- **Mixed methods research:** Utilizes qualitative (interviews, questionnaires, and recordings) and quantitative (analyzing numerical data) research methods.
- **Dual transformation:** A strategy that holds space for the short-term changes needed to bridge disconnects and improve outcomes across existing systems as well as the longer-term work of reimagining new systems that have the potential for transformative change.
- **Equity-centered design: As defined by Every Learner Everywhere, "**Equity-centered design is the practice of purposefully involving minoritized communities throughout a design process with the goal of allowing their voice to directly affect how the solution will address the inequity at hand. Equitable design acknowledges that equity doesn't happen by chance but with intent and focus."[9]
- **Equity-minded inquiry:** Refers to the perspective or mode of thinking exhibited by practitioners who call attention to patterns of inequity in student outcomes.[10]
- **Action research:** Refers to a wide variety of evaluative, investigative, and analytical research methods designed to diagnose problems or weaknesses—whether organizational, academic, or instructional—and help educators develop practical solutions to address them quickly and efficiently.[11] *Action research cycle* refers to a cycle of action or cycle of inquiry, since it typically follows a predefined process that is repeated over time.

Appendix B: Sample Action Plan

We have included a sample action plan for one of the recommendations, which was co-created with members of the Engineering Pathway Collaborative during the final collaborative design session in January 2022. This sample action plan serves to provide concrete, immediate next steps to operationalize the recommendations; the same approach and template can be applied to any of the other recommendations.

Example 1: Professional Development Workstream

Recommendation: Empower K-12 teachers with the necessary skills, tools, habits, and knowledge to help bridge the gap between academic content and career readiness.

Guiding Questions:

1. What types of additional training may be required by K-12 teachers to support students within the engineering pipeline and implement grading for equity practices? What are the primary gaps in teachers' knowledge or pedagogical approaches, and at which grade levels?

2. What are the barriers for teachers to participate in professional development opportunities? What are effective strategies to mitigate these barriers and create incentives for participation?

3. What existing professional development models and resources across the engineering pathway can be scaled or expanded?

4. How might leadership across institutions further support K-12 teachers' professional development needed to achieve engineering pathway goals? What additional policies, practices, and enabling conditions need to be in place?

#	Action Step
1	**Assign specific roles within the engineering pathway** and identify who will be the decision makers and implementers or collaborators for the professional development workstream.

2	**Conduct a curriculum audit, in collaboration with math teachers and faculty across K-12 and higher education institutions** to identify the critical STEM skills that students need to succeed at college-level math. The curriculum audit will help identify and prioritize teachers' key professional development needs to support student learning of these critical STEM skills.
3	**Research professional development strategies to support "grading for equity" practices.** *(These practices may build on existing efforts within the collaborative, such as the Grading for Equity initiative at Reedley College.)*
4	**Identify the key barriers** that stand in the way of teachers engaging in professional development opportunities. *(Some of the barriers already identified by Engineering Pathway members include capacity constraints for teacher time outside of classroom hours and lack of awareness of the professional development opportunities available.)*
5	**Build a consolidated list of the professional development opportunities** and resources available within the engineering pathway, which can be leveraged across institutions. *(This list can build off the resources included within the Findings section of this report.)*
6	**Establish commitments and set targets** for the number of teachers to be trained or who will receive a certification for teaching STEM.
7	**Identify resources and policies needed to reach those targets** (e.g., standard number of pull-out days for teachers to learn outside of the classroom and allocated budget for additional training).
8	**Develop specific interventions and professional development opportunities for teachers** that target the professional development needs (step 2), address the key barriers to engaging in professional development (step 3), and build on the existing resources (step 4). (*One example shared by Engineering Pathway members was to develop a process for sabbatical and internships for teachers to work with local companies or learn within schools.)*
9	**Monitor and assess the efficacy of the professional development opportunities on an ongoing basis** and adjust based on what is and is not working.

Appendix C: Crosswalk of Relevant State-Level Initiatives

This table provides examples of current or proposed state-level initiatives and investments that could be leveraged to advance the recommendations provided in this report. Leaders are encouraged to identify opportunities to move from an engineering pathway defined by a specific grant to a set of shared priorities that will be sustained through braided funding in each system, including the University of California (UC), California State University (CSU), California Community Colleges (CCC), and the California Department of Education (CDE) governing K-12 education.

System Segment(s)	Initiative/Funding Stream	Brief Description	Connection With Engineering Pathway Recommendations
UC, CSU, CCC, K-12	Regional K-16 Collaboratives—Investment from 2021 Budget Act[12]	A competitive grant program to support regional K-16 education collaboratives that create streamlined pathways from high school to postsecondary education and into the workforce	Collaboratives must commit to creating occupational pathways, including accelerated degree and credential programs that incorporate work-based learning in high-priority sectors, including engineering. They must also: • Cultivate inclusive, engaging, and equity-oriented learning environments • Retain students through inclusive supports • Support college preparation and early credit (i.e., dual enrollment) • Participate in the Cradle-to-Career Data System
UC, CSU	Multiyear Compact—Governor's Proposed FY 22-23 Budget[13]	UC and CSU each to receive a 5% annual increase to base funding if certain equity goals are met, including: • Increase enrollment of CA residents	UC and CSU are required to collaborate more with each other and CCCs through combined efforts, including: • Participate in the Cradle-to-Career

		• Increase graduation rates • Eliminate completion gaps by race/ethnicity and Pell Grant status • Establish campus-level retention targets • Improving affordability	Data System and use data to identify equity trends • Develop intersegmental strategies to expand pathways in priority sectors—including technology—and ensure that dual enrollment courses are accepted for transfer credit in CSU and UC • Increase enrollment and completion in STEM disciplines by 25% by 2026-27 • Double opportunities for research assistantships or internships, with an emphasis on underrepresented groups
CCC	CCC Roadmap to California's Future—Governor's Proposed FY 22-23 Budget	Increased funding for the CCCs, with the expectation of meeting goals, including: • Increase degree, credential, or certification completion • Increase transfer rates relative to enrollment growth at UC and CSU • Close gaps in graduation, transfer, and time to completion for traditionally underrepresented students and Pell Grant students • Close equity gaps in dual	Required intersegmental collaboration, including: • Participate in the Cradle-to-Career Data System and use data to identify equity trends • Ensure that dual enrollment courses are accepted for transfer credit and apply toward degree programs Investments for specific purposes, including: • Software that maps intersegmental curricular pathways to help students choose their pathway, facilitate streamlined transfer between segments, and reduce

		enrollment programs	excess units taken on the path to degree or program completion
CCC	Student Equity and Achievement Program	To receive categorical funds from this program, colleges must maintain an equity plan (along with other requirements). These must: • Use data to identify disproportionately impacted (DI) populations, including categories based on race, gender, income, disability, veteran status, and current or former foster youth • Set three-year goals for improving access, success, and completion for the overall student body and DI populations • Identify activities that will support goal attainment for each DI population	Activities funded by student equity plans to target DI groups can include: • Student recruitment • Tutoring, including embedded tutoring • Peer mentoring • Dual enrollment • Student success workshops • Professional development • Outreach to K-12 and community partners
K-12	Local Control Funding Formula (LCFF) and Local Control and Accountability Plans (LCAPs)	To receive LCFF funds, all local education agencies (LEAs) must complete three-year LCAPs that address state and local priorities. As part of the LCAP, LEAs must describe actions being taken to increase or improve services to the following groups of students: foster youth, English learners, and low-income students	Relevant state priorities include: • State standards, including math and science (curriculum, assessment, and professional development) • Parental involvement, including input in decision-making and promotion of parent participation • Pupil achievement, including share of pupils that are college/career ready *(note that the*

			California School Dashboard's College/Career Indicator includes dual enrollment/college course completion as a measure of college/career preparedness).[14] • Course access, including programs and services developed and provided to English learners, students with disabilities, foster youth, and other special populations
K-12	Other Elements of the Governor's Proposed FY 22-23 Budget		• Increased funding for the Expanded Learning Opportunities Program (afterschool and summer programs for students in low-income communities) • One-time funding to support the development of pathway programs focused on technology (including computer science, green technology, and engineering), in partnership with higher education organizations and employers • One-time funding to strengthen and expand access and participation in dual enrollment coupled with advising and support services

References

[1] According to a Reedley College analysis of fall 2019 student participation in Associate of Science degree programs in engineering fields across State Center Community College District institutions, Black students and women were underrepresented across all three colleges. Latinx students were underrepresented at Clovis and Fresno City Colleges, while Asian and Pacific Islander students were underrepresented at Reedley College.

[2] DRIVE Greater Fresno Region, www.fresnodrive.org/.

[3] Fresno K-16 Collaborative: Progress Report 2 (Fresno K-16 Collaborative, December 2021), www.fresnohigheredforall.org/wp-content/uploads/2022/01/Progress-Report-2_Final_Fresno-K16-Collaborative-December-2021-e-version-1.pdf.

[4] Work-Based Learning Framework (Center for Apprenticeship and Work-Based Learning, June 2020), https://jfforg-prod-new.s3.amazonaws.com/media/documents/WBL_Continuum-06-30-20.pdf.

[5] Fresno K-16 Collaborative: Progress Report 2 (Fresno K-16 Collaborative, December 2021), www.fresnohigheredforall.org/wp-content/uploads/2022/01/Progress-Report-2_Final_Fresno-K16-Collaborative-December-2021-e-version-1.pdf.

[6] John Kania, Mark Kramer, and Peter Senge, "The Water of Systems Change," (FSG, May 2018), www.fsg.org/resource/water_of_systems_change/.

[7] See the website www.fresnohigheredforall.org/ for public-facing resources intended to raise awareness of the career opportunities provided in engineering fields, along with the other focal pathways of the Fresno K-16 Collaborative.

[8] Access Regional K-16 Education Collaborative Grant Program Funding (California Department of General Services, 2022), www.dgs.ca.gov/OPSC/Services/Page-Content/Office-of-Public-School-Construction-Services-List-Folder/Access-Regional-K-16-Education-Collaboratives-Grant-Program-Funding.

[9] How Equity-Centered Design Supports Anti-Racism in the Classroom (Every Learner Everywhere Network, 2021), https://www.everylearnereverywhere.org/blog/how-equity-centered-design-supports-anti-racism-in-the-classroom/.

[10] What is Equity-Mindedness? (USC Center for Urban Education), https://cue.usc.edu/equity/equity-mindedness/.

[11] Action Research (Great Schools Partnership, May 2015), www.edglossary.org/action-research/.

[12] Access Regional K-16 Education Collaborative Grant Program Funding (California Department of General Services, 2022), www.dgs.ca.gov/OPSC/Services/Page-Content/Office-of-Public-School-Construction-Services-List-Folder/Access-Regional-K-16-Education-Collaboratives-Grant-Program-Funding.

[13] Governor's Budget Summary: Higher Education 2022-2023, www.ebudget.ca.gov/2022-23/pdf/BudgetSummary/HigherEducation.pdf.

[14] California Department of Education, "College/Career Readiness Calculation," accessed February 10, 2022, www.cde.ca.gov/ta/ac/cm/ccical.asp.