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TALENT PIPELINES FOR THE FOURTH INDUSTRIAL REVOLUTION: How California PaCE Units Can Bridge Critical KSA Gaps

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ABSTRACT
This paper presents a rationale for using professional and continuing education (PaCE) units at post-secondary institutions throughout California to design and implement talent-pipelines, research and development collaborations, and other knowledge ecosystems where emerging and returning professionals can acquire the knowledge, skills, and abilities (KSAs), as well as the experience, they need to address the challenges of the Fourth Industrial Revolution (4IR). The paper provides an analysis of the reasons why PaCE units are uniquely positioned to address the needs of industry and job seekers, and on a timetable that keeps pace with 4IR velocity.

Keywords:
Fourth Industrial Revolution, talent pipelines, knowledge ecosystems, Professional and Continuing Education

INTRODUCTION

Industrial revolutions compelled changes in learning and development priorities decades before California established statehood in 1850. When Thomas Jefferson became president of the American Philosophical Society in 1797, the leading scientists and equivalent humanities specialists of the time "could be seated comfortably in the lecture room of a philosophical hall. Most could discourse reasonably well on the entire world of learning, which was still small enough to be seen whole."[1] Jefferson's tenure as APS President coincided with the First Industrial Revolution, when new machines driven by steam and waterpower were redefining transportation, industrial, and public infrastructure systems. Two centuries later, amid the Fourth Industrial Revolution (4IR), it is no longer possible to gather in one lecture room to discuss "the entire world of learning." In 2024, the number of disciplinary specialists required to adequately represent expertise in science, technology, engineering, arts, and mathematics fields would fill seats in lecture rooms throughout California, the United States (U.S.), and countries throughout the world.

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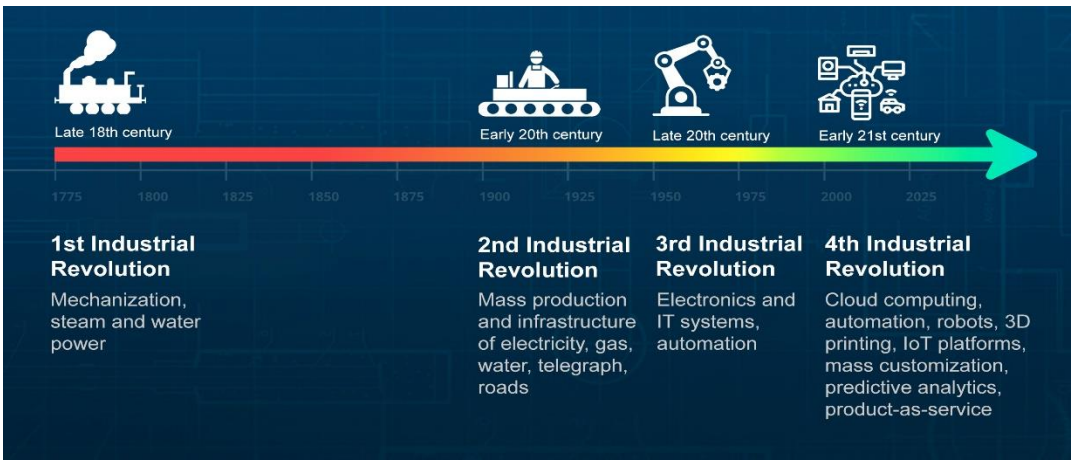
[1] Edward Osborne Wilson, *Consilience: The Unity of Knowledge* (New York: Alfred A. Knopf, Inc., 1998), p. 42-23.

Figure 1: Timeline of Industrial Revolutions.



In response to technological shifts[2] driven by the 4IR, leaders in higher education are struggling to develop education and training programs that keep pace with the "unprecedented velocity" and "fusion of the digital, physical, and biological spheres"[3] that define the 4IR. Technological transformations associated with the 4IR are creating knowledge, skills, and abilities (KSA) gaps that pose intractable challenges for employers.[4] In response, leaders in industry, government, and education are using talent-pipeline programs to provide collaborative frameworks for leaders in academia, government, and industry to bridge critical KSA gaps. Professional and Continuing Education (PaCE) units, based in colleges and universities throughout California, provide flexible and adaptable environments to pilot, refine, and scale talent-pipeline programs to empower emerging, incumbent, and displaced professionals of the 4IR workforce.[5]

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[2] Thomas S. Kuhn, *The Structure of Scientific Revolutions*, 3rd ed. (Chicago, Illinois: University of Chicago Press, 1996 [originally published 1962]).

[3] Klaus Schwab, *The Fourth Industrial Revolution* (New York: Crown, 2017); Klaus Schwab, "Foreword," *Journal of International Affairs* 72, no. 1 (2018): 13–16. https://www.jstor.org/stable/26588338; Klaus Schwab, "The Fourth Industrial Revolution: What It Means and How to Respond," *World Economic Forum*, January 14, 2016. https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/.

[4] On technological changes and skill impact resulting from the 4IR, see for example, Klaus Schwab, *The Fourth Industrial Revolution* (New York: Crown, 2017) *and* Nancy W. Gleason, ed., *Higher Education in the Era of the Fourth Industrial Revolution* (Singapore, Singapore: Palgrave Macmillan Singapore, 2018), https://link-springer-com.csulb.idm.oclc.org/book/10.1007/978-981-13-0194-0;. On the need for regulation and the importance of social power in addressing challenges and opportunities presented by technological change, including impact on employment and inequality, see for example Daron Acemoglu and Simon Johnson, *Power and Progress: Our 1000-Year Struggle Over Technology & Prosperity* (New York: Public Affairs, 2023). On the opportunities new technologies like artificial intelligence (AI) provide to overcome skills gaps and restore middle-skill and middle-class jobs see David Autor, "Applying AI to Rebuild Middle Class Jobs," NBER Working Paper Series No. 32140, February 2024, https://www.nber.org/papers/w32140.

[5] Tyler D. Reeb and Stacey Park, "Trade and Transportation Talent Pipeline Blueprints: Building University-Industry Talent Pipelines in Colleges of Continuing and Professional Education" (San José, CA: Mineta Transportation Institute, February 2023), https://transweb.sjsu.edu/sites/default/files/2144-Reeb-Trade-Transportation-Talent-Pipeline-Blueprints_0.pdf.

This paper presents a call to action for post-secondary education leaders to utilize tools offered through PaCE units to design and implement talent pipelines, learning and research development collaborations, and other knowledge ecosystems where emerging, incumbent, and displaced professionals can acquire KSAs and experiences to prepare them for workforce challenges. The American Association of State Colleges & Universities noted in a recent employer survey: "The diverse institutions that constitute American higher education are critical architects and co-designers, alongside industry and community partners, of an economic future in which all students have the opportunity to thrive."[6] The need to emphasize co-constitutive roles of industry and post-secondary education stems from slow acceptance of the university's "connector" role,[7] and reticence to adapt and change.[8] This emphasis on co-creating impact is coincident with the value of college credentials being increasingly questioned even if only because of cost.[9] Often, policies and practices "designed for an analog era" prompt businesses and individuals to look elsewhere to meet educational and experiential needs as they see post-secondary education as slow to respond to an increasingly complex job market.[10]

Universities are large, complex organizations that have historically distributed responsibilities for addressing career education to individual units, be they business schools, campus career centers, or other professional program units. Many students are omitted from these efforts, however, or do not realize the value of the services offered. A recent National Association of Colleges and Employers survey notes that nearly half of undergraduate students surveyed either waited until fourth year to visit career centers or never visited prior to graduation.[11] That same survey notes that student career center visits were primarily for help with resume writing or general career advice, not for the skill development aligned with specific employer or industry based talent needs.[12] For California to meet the ambitious post-secondary credential attainment goal of 70% by 2030,[13] and implement a robust Masterplan for Career Education, [14] post-secondary educators and administrators must look beyond traditional models of degree completion and

[6] Ashley P. Finley, *The Career Ready Graduate: What Employers Say About the Difference College Makes* (Washington, D.C.: AAC&U, 2023), p. 35.
[7] On the university as a "connector" see: Peter Wiseman and Mia Juritzen, "University as Connector" How Universities Can Align Industry Needs and Student Demand Using Data," Nous Group, May 2023.
[8] See, for example, Brian Rosenberg, *"Whatever it is, I'm Against It": Resistance to Change in Higher Education*, (Cambridge, MA: Harvard, 2023).
[9] Survey data are mixed on the question of "value" with older American's confidence in higher education down sharply according to Gallup polling (https://news.gallup.com/poll/508352/americans-confidence-higher-education-down-sharply.aspx), while further Gallup polling also shows Gen Z more positive about higher education overall, with concerns mostly about affordability (https://news.gallup.com/opinion/gallup/509906/majority-gen-consider-college-education-important.aspx)
[10] See, for example, Douglas Belkin, "Why Americans have Lost Faith in the Value of College: Three generations of 'college for all' in the U.S. has left most families looking for alternatives," *Wall Street Journal*, https://www.wsj.com/us-news/education/why-americans-have-lost-faith-in-the-value-of-college-b6b635f2
[11] National Association of Colleges and Employers, "The 2023 Student Survey Report: Attitudes, Preferences, and Outcomes of Bachelor's Degree Students at Four-Year Schools," p. 9. https://naceweb.org, accessed January 27, 2023)
[12] Ibid, p. 9
[13] Office of Governor Gavin Newsom, "The California Blueprint: Strengthening Our World-Class Higher Education System" (CAWeb Publishing Service, January 2022), https://www.gov.ca.gov/wp-content/uploads/2022/01/Higher-Education-Fact-Sheet.pdf.
[14] "Master Plan for Career Education," *California Governor's Council for Career Education*, accessed April 12, 2024, https://careereducation.gov.ca.gov/master-plan-engage/.

career services by articulating value and aligning skill building with employer and industry needs. There, PaCE and talent pipelines can serve increasingly important roles.

PaCE was established in the State's Education Code explicitly to provide the flexibility necessary to meet contemporary and future needs while offering access to underserved populations and adult learners. Maneuvering under the same educational policies as the CSU system, but outside state-funded mandates, PaCE ensures California can meet a lifetime of educational needs for its citizens.[15] John Seely Brown, Director of the PARC Lab at Xerox, "wrote that the half-life of a skill is five years (and shrinking). While we might quibble about when skills become obsolete exactly, I think we can all agree that the 21st century world of work does not predict we ever really graduate—we must be life-long learners if we are to thrive."[16]

The needs of job seekers and employers demand that post-secondary education play a more direct workforce intermediary role. To do this, PaCE programming must be fully integrated into the core mission of post-secondary education[17] and must scale program development driven by community readiness models[18] of engagement that work more directly with industry and community partners to ensure broad-based and equitable access to skills and good jobs.[19] When implemented effectively, talent pipelines

[15] "Through extended education operations (also known as "special sessions" as defined in Education Code section 89708 or known as "continuing education" as it appears in Education Code section 89704), the CSU provides educational opportunities on a self-supporting basis to specialized audiences and local communities across the state and nation, and internationally." See California State University policy "Extended Education; Self-Supporting Instructional Courses and Programs" (https://calstate.policystat.com/policy/10548254/latest#autoid-v2y9x).

[16] John Seely Brown as referenced by Jane Close Conoley, California State University Long Beach President, and current Chair of the California State University Commission on Professional and Continuing Education. https://www.calstate.edu/attend/CPaCE/About-Us (accessed January 27, 2024); Douglas Thomas and John Seely Brown, *A New Culture of Learning: Cultivating the Imagination for a World of Constant Change* (Lexington, KY: CreateSpace, 2011), https://www.johnseelybrown.com/.

[17] *On the need to change traditional models of extension and imbed professional and continuing education into universities core mission see, for example:* Elizabeth H. Simmons and Hugo Villar. "Evolving 'Extension,'" *Inside Higher Ed*, July 21, 2023, Accessed August 28, 2023: https://www.insidehighered.com/opinion/views/2023/07/21/why-and-how-we-rethought-role-extension-opinion.

[18] Ruth Edwards et al., "The Community Readiness Model: Research to Practice," *American Journal of Community Psychology* 28, no. 3 (May 2000): 293–307, https://doi.org/10.1002/(SICI)1520-6629(200005)28:3<291::AID-JCOP5>3.0.CO;2-9; Leigh Anne Michael, "Community Readiness for Economic Development: Assessing Readiness for Ocean Renewable Energy Along the Oregon Coast," *University of Oregon Scholars Bank*, June 2014, oai:scholarsbank.uoregon.edu:1794/18236; E. R. Oetting et al., *Community Readiness for Community Change: Tri-Ethnic Center Community Readiness Handbook*, ed. Linda R. Stanley, 2nd ed. (Tri-Ethnic Center for Prevention Research (Colorado State University), 2014), www.TriEthnicCenter.ColoState.edu.
For a brief overview of Tyler Reeb's work on community readiness models with Ron Hall (Tribal Transportation Program Manager, Upper Great Plains Transportation Institute, NDSU, Co-Director, Northern Tribal Technical Assistance Program) and Cameron Ishaq (Operations Manager, the National Center for Rural Road Safety), see: CITT Staff, "Western NLTAPA Regional Meeting Highlight: Community Readiness Models to Address Mobility Needs in Tribal Communities," *CITT News*, May 17, 2023, https://www.cpace.csulb.edu/news/article/western-nltapa-regional-meeting-highlight-community-readiness-models-to-address-mobility-needs-in-tribal-communities.

[19] *On "good jobs" see:* Zeynep Ton, "The Case for Good Jobs," *Harvard Business Review*, November 30, 2017: https://hbr.org/2017/11/the-case-for-good-jobs; Zynep Ton, *The Case for Good Jobs: How Great Companies Bring Dignity, Pay, and Meaning to Everyone's Work*, Brighton, MA: Harvard Business Publishing, 2023.
Higher education (and colleges of professional and continuing education in particular) will need to be focused on good jobs as it pertains to "gainful employment." On updates to current federal regulations, see: Katherine Knott, "New, Stronger Gainful Employment Regs Released," *Inside Higher Ed*, May 18, 2023, Accessed August 29, 2023.

provide clear value to the learner, the educator, and the employer. For learners, the talent pipeline ensures they are not wasting but rather investing their time and money into acquisition of in-demand KSAs. For educators and employers, talent pipelines instantiate the value of investing in educational programs that empower learners of all ages to realize their potential. Thus, it is important to engage and educate the communities who can benefit most from talent-pipeline programs. One successful talent-pipeline implementation could help one person break the poverty cycle—a network of PaCE-led talent pipelines could help thousands of Californians break the poverty cycle and realize career potentials.

PaCE units are uniquely positioned to address the needs of industry and job seekers, and on a timetable that keeps pace with 4IR. Here we analyze two pilot talent-pipeline programs designed to address mission-critical KSAs for emerging data science and intelligent transportation systems (ITS) careers. These pilots were selected for three central reasons:

1. Both directly address a wide range of transformational technologies: cloud computing, connected devices, smart communities, automation, robots, Internet of Things platforms, human-machine interfaces, predictive analytics, and continued digitization of work processes;
2. Both were codeveloped with industry partners (Gannett Fleming, a global engineering firm, and Jet Propulsion Laboratory (JPL), a global leader in space exploration and satellite technology) that committed resources to recruit, onboard, and provide paid internships for students; and
3. Both were developed within a California PaCE unit using self-support funds to demonstrate proof-of-concept to internal and external partners in support of future deployments on other campuses. Working in a self-support status made it possible to avoid institutional hurdles and delays associated with state-funded initiatives offered in traditional campus units.

TALENT PIPELINES: CONNECTING EDUCATORS AND EMPLOYER TO ADDRESS WORKFORCE DEMANDS

Although healthcare programs have demonstrated for decades that talent pipelines provide an efficient collaborative framework for educators and employers to validate critical KSAs, more research is required in other disciplines and economic sectors to identify ways to implement talent-pipeline programs. After "conducting substantial research and interviewing dozens of senior leaders and experts," the President's National Infrastructure Advisory Council "found that the workforce development system in the United States lacks the coordination, data, and strategic human capital management necessary to ensure a skilled workforce for critical infrastructure." The report identified "risks to national security posed by barriers to enhance the Nation's talent pipeline," which could have "dire consequences for economic stability, public safety, and national security."[20] Talent pipelines provide a strategic approach to developing a skilled workforce—calling upon university and industry leaders to undertake systematic identification, cultivation, and progression of learners (Figure 2) to meet current and future workforce needs.

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https://www.insidehighered.com/news/government/student-aid-policy/2023/05/18/new-stronger-gainful-employment-regs-released; Phil Hill, "Visualizing If Gainful Employment Applied To Most Degree Programs," *OnEdTech*, May 22, 2023: https://philhillaa.com/onedtech/visualizing-if-gainful-employment-applied-to-most-degree-programs/; Phil Hill, "Friday Gainful Updates," *OnEdTech*, August 18, 2023: https://philhillaa.com/onedtech/friday-gainful-updates/.

[20] "Workforce and Talent Management Study" (Washington, D.C.: National Infrastructure Advisory Council (NIAC), September 2021), https://www.cisa.gov/sites/default/files/publications/NIAC_Workforce%20and%20Talent%20Management%20Study_Final%20508.pdf.

Figure 2: Education and Career Readiness. The White House (2022). Fact Sheet: The Biden-Harris Administration launches the Talent Pipeline Challenge: Supporting employer investments in Equitable Workforce Development for Infrastructure Jobs

To forge meaningful talent-pipeline partnerships with public- and private-sector employers, leaders in higher education must address institutional hurdles in traditional campus units dedicated to four-year and graduate-degree programming. PaCE units provide the flexible education and training options required to support the piloting, refining, and scaling of talent-pipeline programs, which provide a collaborative framework for leaders in academia, government, and industry to bridge critical KSA gaps. Successful talent-pipeline partnerships are driven by the industries they serve and developed in collaboration with internship hosts. What all talent-pipeline models have in common is that they reconfigure traditional training models and prepare and validate more hirable candidates.

It is important to establish that while talent-pipeline programs contain elements of apprenticeships and internships, they are scaffolded by the full suite of PaCE education and training products that make it possible for educators and employers to overcome the institutional barriers encountered in traditional colleges.

California State University, Long Beach President Jane Conoley championed innovative ways that PaCE units can empower learners of all ages in an August 2023 briefing to the California State University (CSU) Commission on Professional and Continuing Education.

> We anticipate that individuals will need access to both short and long-term educational opportunities that provide different types of credentials, from stackable certificates to complete academic degree programs. Expanding and developing degree and certificate programs through PaCE, with a focus on programs that 'meet students where they are' with simple, per unit pricing,

> multiple admission cycles, and other key features now present in much of the higher education market is essential. [21]

Conoley noted that "all twenty-three universities [in the CSU system] plan to expand their academic portfolios to include short skills-oriented courses, industry certifications, degree completion programs, and graduate degrees in high-need areas related to the California workforce.[22]

Conoley, who chairs the statewide CSU Commission on Professional and Continuing Education, shared other recommendations for PaCE education that would support innovative talent-pipeline program development, including:

1. Further integration and support for credit for prior learning;
2. Revisions to CSU policy "Extended Education; Self-supporting instructional courses and programs and Title 5 of the Education Code";
3. Increased online education to support the needs of adult and professional learners in shorter course and often asynchronous formats; and
4. Prioritizing the needs of adult learners as traditional populations of high school graduates increasingly decline in the years ahead.

To study the efficacy of talent pipelines in addressing 4IR KSA gaps, the authors implemented two pilots, hypothesizing that the programs would better prepare participating learners to succeed in subsequent paid positions. These pilots differ from existing internship programs in three key ways; they: 1) have built-in accountability and flexibility in programming through collaborative industry-university partnerships; 2) have direct support from industry partners to 'pre-train' potential interns; and 3) address, in real time, changes in industry practices.

STUDY METHODS AND RESULTS

The two case studies address ITS cohort preparation for Gannett Fleming and a data science aptitude for JPL. Students participated in the ITS cohort and JPL workshop expecting to gain an understanding of the KSAs required for an internship at Gannett Fleming or JPL. Participating students were informed that 10% or fewer would receive a paid internship. Flyers (see Appendix A) were posted and shared.

These case studies targeted a small number of students, 25 and 3 for JPL and Gannett Fleming respectively, which invites questions about scalability. However, output from talent pipelines must not exceed demand, so scaling must be carefully proportioned. If only a small proportion of participants win the targeted positions, the others will gain little to no benefit. Some industries will lend themselves to large-group trainings (e.g., the nascent hydrogen fuel industry in California), but in most cases, scaling will require a greater number of industry participants, rather than a greater number of student participants. Workforce demands will drive industry participation in talent pipelines, but institutions that develop such programs will undoubtedly implement recruiting initiatives—especially as the number of programs increases and competition between programs grows.

[21] Jane C. Conoley, "PaCE Rationale for Action 080123" (CSU Commission on Professional and Continuing Education, August 1, 2023).
[22] Ibid.

ITS Cohort Preparation for Gannett Fleming

Gannett Fleming is an architectural, engineering, and systems design consulting firm with a national portfolio of intelligent transport systems (ITS) and transportation infrastructure projects. With a multidisciplinary team of more than 2,800 professionals and 50+ offices across North America, Gannett Fleming has a well-established internship program. The ITS talent pipeline was initially proposed in a Mineta Transportation Institute report as a 'proof-of-concept' for such programming. Gannett Fleming leadership confirmed official support for the pipeline during a November 2022 launch meeting at CSULB within the PaCE unit and led by the Center for International Trade and Transportation (CITT); Gannett Fleming leadership committed to providing paid summer internships for CSULB students who completed the first segment of the talent-pipeline program. Gannett Fleming also committed to coordinating talent-pipeline activities with CITT during the summer internship phase. These commitments signaled a critical prerequisite for any successful talent-pipeline initiative: "skin in the game."[23]

CSULB and Gannett Fleming teams worked with pipeline participants to produce videos reflecting important KSA milestones they met. During completion of the university-led portion of the talent pipeline, members of the pilot cohort recorded summary videos that demonstrated their onboarding, presentation skills, understanding of multidisciplinary teamwork, project-management skills, and familiarity with ITS technologies (written summaries evaluating the ITS case-study curriculum are featured in Appendix C). Upon completion of the summer internships, pilot cohort members recorded videos that demonstrated their ability to provide a project briefing to a team. To guide implementation of the pilot program, CSULB and Gannett Fleming teams implemented a series of steps addressing what the Stanford Social Innovation Review defines as the five conditions of collective impact: common agenda, shared measurement, mutually reinforced activities, continuous communication, and backbone support (see Table 1; Appendix A).

Through a combination of historical and real-time labor market analysis by CITT and input from Gannett Fleming about skills gaps and hiring challenges, the collective pilot team agreed upon the following objectives for the ITS cohort:[24]

- A general understanding of ITS and its foundational concepts by embedding case-study module topics in CSULB College of Engineering courses during spring 2023;
- Linking CSULB to ITS subject matter experts at outside universities and incorporating industry expert guest speakers;

[23] Jason A. Tyszko and Robert G. Sheets, "Building the Talent Pipeline: An Implementation Guide," Talent Pipeline Management (Washington, D.C.: U.S. Chamber of Commerce Foundation, November 11, 2015), https://www.uschamberfoundation.org/reports/building-talent-pipeline-implementation-guide. *See specifically the section "Strategy 1: Organize Employer Collaboratives" (pp. 6-12). See also:* Jason A. Tyszko, Robert G. Sheets, and Joseph Fuller, "Managing the Talent Pipeline: A New Approach to Closing the Skills Gap" (Washington, DC: U.S. Chamber of Commerce Foundation, 2014), U.S. Chamber of Commerce Foundation TPM Resources, https://www.uschamberfoundation.org/sites/default/files/media-uploads/Managing%20the%20Talent%20Pipeline_0.pdf.

[24] Analyzing the labor market for transformational fields requires a blend of historical labor market analysis from U.S. Bureau of Labor Statistics data (largely derived from census and community survey data) and real-time data. Historical data in some cases does not capture critical occupations and new KSA gaps, but it does provide a way of understanding where the labor market is going. Real-time analysis, using tools like *LightCast*, make it possible to study current job descriptions posted by employers. This real-time snapshot has limitations, too, but provides an alternative perspective to assess changing workforce development challenges.

- Prioritizing industry KSAs; and
- Identifying ways to scale the single-employer talent pipeline to larger statewide and national implementations.

Two of three initial members of the ITS pilot were selected by Gannett Fleming to serve as paid summer interns. One intern was a civil engineering major with a focus on transportation, the other was an economics major who made a strong case to be considered for the pipeline despite its engineering focus. Reports from Gannett Fleming indicate that both interns exceeded expectations. The engineering student met the expected outcomes of the pilot. The economics student validated findings from Gannett Fleming's advanced mobility division. Gannett Fleming and CITT teams also coordinated to have a third computer science graduate student complete the ITS pilot as a paid research assistant on a federally funded ITS project. The computer science graduate student is serving on a real-world ITS community test-bed project funded by Caltrans and the U.S. Department of Transportation under the oversight of the CITT team; findings from that research will be available August 2024.

As established in earlier examinations of 4IR KSA gaps, problems of the future will not exist or be solved within one disciplinary silo. Academic disciplines emerge and institutionalize slowly. Skill gaps, as we have witnessed, widen rapidly – at the pace of technological change. Talent pipeline programs facilitated by PaCE can operate in the middle, adding value without generating excessive demands on existing university faculty or programs. In the 4IR, just as physical, biological, and digital spheres are melding, so too are traditional disciplinary boundaries of domain knowledge.

Data Science Workshop for Jet Propulsion Laboratory (JPL)

JPL is a federally funded research and development center located in Pasadena, California. The laboratory is a collaboration between the National Aeronautics and Space Administration (NASA) and the California Institute of Technology, and its primary functions are construction and operation of planetary robotic spacecraft, conducting Earth-orbit and astronomy missions, and operating the NASA Deep Space Network. JPL has a well-established internship program.[25]

Weeks after the launch of the ITS pilot, Earth Science researchers at CSULB and JPL contacted the authors with the idea of implementing a data science pilot in Spring 2023. Given the compressed timeline, a workshop model was employed. The motivation for the JPL-CSULB talent-pipeline pilot arose from a desire to diversify JPL internship cohorts by attracting students from backgrounds traditionally underrepresented in the STEM workforce. CSULB was an ideal partner for JPL to address this important institutional priority given that 51% of CSULB students are from traditionally minoritized races/ethnicities, 71% are non-Caucasian, and more than half are Pell Grant eligible (39%) and/or first-generation college students (31%). To ensure equitable accessibility to participation, the workshop was held on the CSULB campus, and each participant received $200 to offset any loss in pay experienced by devoting two days to the workshop.

The JPL workshop involved a 10-hour data science interactive training (over a Friday and Saturday in April) at CSULB and designed and led by JPL researchers. JPL created an online portal for participants to access various data sets of satellite-generated information and a computer sandbox where participants carried

[25] "Student Programs," Federally Funded Research and Development Center funded by NASA and managed by Caltech, Jet Propulsion Laboratory, 2023, https://www.jpl.jobs/students-and-postdocs.

out data science activities. The collective pilot team agreed upon the following objectives for the workshop:

- A general understanding of satellite-enabled data science and its foundational concepts associated with climate change and sea-level rise;
- Linking CSULB to JPL subject matter experts; and
- Prioritizing data science KSAs (e.g., coding, statistical analyses, and related ecological knowledge).

The workshop comprised alternating explanations of sea-level rise and loss of sea ice and data manipulations, both guided by the JPL researchers. In total, 25 CSULB undergraduate and graduate students completed the workshop. Of those participants, two were employed by JPL as paid summer interns, and five are awaiting internship placement for the 2023-24 academic year.

ASSESSMENT OF TALENT-PIPELINE PILOT PROGRAMS

The impact of the CSULB pilots launched in partnership with JPL were assessed by surveys completed by workshop participants. The authors also surveyed various personnel from industry (JPL and Gannett Fleming) and CSULB to assess general opinions on internship programs, industry-university partnerships, and preparation of students for careers after graduation. Prior to deployment, the surveys were submitted to the CSULB Institutional Review Board, who waived the need for a full review because they presented little risk to participants whose anonymity was assured.

Students who participated in the data science workshop for JPL were invited to complete pre- and post-participation surveys (see Appendix B). To explore broader talent-pipeline themes, employees from Gannett Fleming, JPL, and CSULB as well as community advisors for CSULB programs, were invited to complete a stakeholder survey.

JPL Student Pre-Participation Survey

Twenty-nine prospective students completed the pre-participation survey (although only 25 were able to take part in the workshop). Top motivators for student participation were participation in data science and career exploration and preparation. Of the 25 workshop participants, 37% reported enrolling because a faculty member sent them the flyer and encouraged them, 16% enrolled after seeing the flyer posted at CSULB, and 47% enrolled after being encouraged and/or seeing the flyer reposted on various social media platforms. It is noteworthy that the organizers did not post to social media or request that others do, rather faculty posted the workshop information on social media and students reposted it. Thus, an effective recruitment plan should include direct encouragement as well as posting and requesting reposting on social media.

All respondents expected to develop KSAs related to data science, with 66% referring to data science in general and 34% identifying specific data science tools and techniques they expected to learn. Additionally, 26% of respondents reported expectations to gain KSAs in networking, teamwork, problem solving, and critical thinking.

Student Post-Participation Survey

Twenty-five students completed the participant survey. With respect to KSAs acquired, 52% of workshop participants reported gaining data science KSAs, 30% reported gaining other career-related KSAs, and 18%

reported gaining both types of KSAs. These survey findings were not mutually exclusive, but rather a self-selecting indication of learner preferences. Attempts to expand and scale related talent-pipeline deployments on a broader scale should include quantitatively significant respondent populations paired with measurement and tracking mechanisms to ensure the ability to conduct longitudinal analyses to test and refine the efficacy of future efforts. All but two respondents who took the survey had prior experience with career-development or internship-related workshops, and of those 52% said the talent-pipeline workshop was better than their previous experiences and 48% said it was much better.

Stakeholder Survey

The stakeholder survey was completed by 95 individuals (85 from CSULB and 10 from industry). Their top three priorities when mentoring students for professional development were: 1) over-and-above academic activities/opportunities; 2) providing guidance concerning further education; and 3) promoting experiential learning opportunities. Eighty-five percent of respondents said that students were well prepared for research-oriented careers and 77% affirmed that students are aware of career paths that would be a 'good fit' for the KSAs they were developing. Additionally, 69% of respondents said current open-opportunity, professional guidance events and activities are beneficial for students and 73% said talent-pipeline activities should be open to any student regardless of degree path. The opinion that talent-pipeline activities should be accessible to any interested student from any degree path reflects stated opinions that multidisciplinary approaches yield the best solutions to challenges in industry and government.

In debriefings, Gannett Fleming and JPL teams reported highly positive experiences and a desire to repeat the talent-pipeline activities in the future. Those from JPL found their interns well-prepared to immediately begin project work for the summer, while those from Gannett Fleming found that onboarding activities from the ITS pilot prepared interns to work on project teams. These findings reflect the advantage of a pre-internship workshop led by the host company. Indeed, Gannett Fleming plans to implement the workshop model for a future talent pipeline.

LESSONS LEARNED AND NEXT STEPS FOR SCALING PIPELINES STATEWIDE

During the November 2022 launch for the ITS pilot, the National Operations Center of Excellence committed to work with the CSULB and Gannett Fleming teams to "connect students to a wide range of ITS career opportunities and trainings" and support expansion of the "single-employer talent-pipeline pilot into a coalition-led model." This method of transitioning from single-employer- to coalition-led talent pipelines (see Figures 3 and 4) could be applied to a wide range of industries by building upon the organizational framework of the Center's annual Transportation Technology Tournament [26], where

[26] "Transportation Technology Tournament," National Operations Center of Excellence, August 23, 2023, https://transportationops.org/transportation-technology-tournament.

Figure 3: Single-Employer Talent Pipeline.

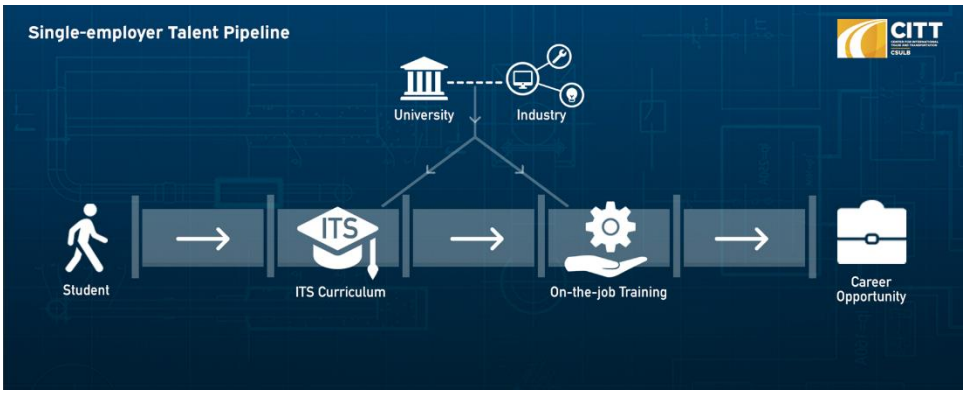
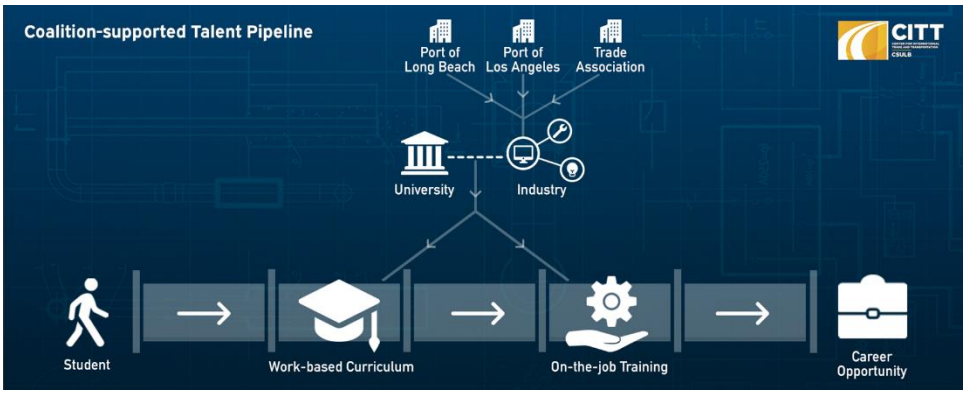


Figure 4: Coalition-supported Talent Pipeline.



student teams work with departments of transportation, municipal planning organizations, or transit agencies to "define a transportation problem." The teams of students, guided by an academic advisor, utilize their burgeoning KSAs to develop solutions addressing the originally defined problem. The tournament concludes with teams presenting solutions to a panel of judges who select the annual tournament winner. The tournament occurred annually from 2018 to 2023, with 121 graduate and 120 undergraduate students from 31 universities in 16 states participating. Although not formally called a talent pipeline, this tournament includes modular training like the curriculum associated with ITS and JPL pilots.

PACE UNITS AS FACILITATORS OF TALENT PIPELINES

Considered through a historical lens, PaCE units have played an important role in preparing a nation of learners to respond to the challenges created by the first three industrial revolutions. Over the last century, educators and policymakers have worked to support the design, development, implementation, and evaluation of programs associated with *extended*, *continuing*, *professional*, and *career-and-technical education* and have revised these categories in response to changing workforce challenges and related KSA gaps generated by new industrial demands. The Smith-Hughes Act of 1917 demonstrated a federal recognition that the Second Industrial Revolution—with its booms in mass production, infrastructure, electricity, gas, water, telegraph, and roads—required a new era of PaCE programs to develop a skilled

labor force.[27] In service of this new federal PaCE priority, the Smith-Hughes Act supported programs to train teachers to teach vocational programs.[28]

The 2019 reauthorization of the Carl D. Perkins Vocation Education Act signaled another redefinition of education priorities in response to the 4IR. The revised legislation prioritized attainment of technical skills and industry-recognized certificates and credentials within a broader context that supported increased access to post-secondary degrees. The legislation established new priorities that, much like the response to prior industrial revolutions, called for new education and training priorities to help learners develop the KSAs needed to succeed as entry-, mid-, and senior-level.[29] The focus on vocational programs in the earlier Smith-Hughes legislation signaled a national focus on training for skills directly connected with specific occupations. Throughout the 20th Century, vocational training increasingly became associated with fields referred to as "trades" with carpenter, machinist, plumber, and electrician often cited as representative and in-demand careers. Later revisions in the Act called for blending vocational skills-based education and academic training associated with post-secondary degree opportunities, which provided legislative acknowledgment that 4IR workforce challenges call for new hybrid KSAs.

For most leaders in higher education, keeping pace with the velocity of the 4IR is not compatible with traditional timetables for degree programming and curricular development even when faced with government demands that post-secondary education meet workforce needs. Traditional degree programs are often incompatible with the needs of working professionals seeking to acquire new KSAs to remain competitive in the workplace. Micro-degrees, stackable credentials, micro-credentials, and badges have been proposed to address these demands; however, they too have incompatibilities with the traditional academic structure of higher education.[30] Talent-pipeline programs provide an iterative and integrated framework for subject-matter experts in industry, government, and education to collaboratively address workforce and research development incompatibilities. PaCE units are uniquely positioned within higher education to serve as an additional workforce intermediary and thus directly address the needs of the workforce and employers.[31] PaCE units help universities serve as connectors to facilitate learner access to

[27] Jay Stratte Plasman, Michael A. Gottfried, and Ethan L. Hutt, "Then and Now: Depicting a Changing National Profile of STEM Career and Technical Education Course Takers," *Teachers Colleges Record* 122, no. 2 (February 2020): 1–67, https://doi.org/10.1177/016146812012200209.

[28] Ann Y. Kim, Tyler Reeb, Jaylee Jordan, and Youngjin Song, "Curriculum Evaluation of the Academy of Global Logistics Program: Connections STEM Education" (San José, CA: Mineta Transportation Institute, June 2023): https://rosap.ntl.bts.gov/view/dot/68036.

Hoke Smith and D.M. Hughes, Vocational Education Act of 1917 (or Smith-Hughes Act of 1917), Pub. L. No. 64–347, § 703, U.S.C. 929 (1917): https://uscode.house.gov/statviewer.htm?volume=39&page=929.

For more information on Career and Technical Education, see: Jay Stratte Plasman, Michael A. Gottfried, and Ethan L. Hutt. "Then and Now: Depicting a Changing National Profile of STEM Career and Technical Education Course Takers." *Teachers Colleges Record* 122, no. 2 (February 2020): 1–67. https://doi.org/10.1177/016146812012200209.

For more information on the Smith-Hughes Act, see: David Carleton, "The Smith–Hughes Act (February 23, 1917)" in *Landmark Congressional Laws on Education*, 63–76 (Westport, Connecticut: Greenwood Press, 2002): https://books.google.com/books?id=DraaG0UyOdIC&pg=PA63#v=onepage&q&f=false.

[29] Strengthening Career and Technical Education for the 21st Century Act, Pub. L. No. 115–224, U.S.C. (2018). https://www.congress.gov/bill/115th-congress/house-bill/2353.

[30] Sean Gallagher, *The Future of University Credentials: New Developments at the Intersection of Higher Education and Hiring*, Cambridge, Massachusetts: Harvard Education Press, 2016.

[31] *On post-secondary institutions as workforce intermediaries see, for example:* Nichola Lowe, *Putting Skill to Work: How to Create Good Jobs in Uncertain Times*, Cambridge, MA: The MIT Press, 2023.

education responsive to industry skill demands.[32] Examples of such connectors include talent pipelines, which are intentionally developed in partnership with industry and government to address specific, industry-wide, and inter-industry needs.

Given the nimbleness of PaCE relative to the academic core of most post-secondary institutions, pipelines provide vehicles for rapid response to mission-critical KSAs. Talent pipelines can take many forms: from workshops or bootcamps to more traditional apprenticeship or internship programs run in parallel to, or embedded in, more traditional, but often self-supporting, undergraduate degree completion and graduate master's degree programs. Additionally, PaCE units can support modular, stackable program offerings that create additional skill development pathways with flexible on and offramps for learners as they navigate the job market or as employers implement training for KSA needs that change over time.

Using self-support funding, leaders in industry and government can partner with PaCE educators to design and deploy pilot programs to test working relationships between educators and employers and to develop KSA-infused curricula. By using pilot programs, higher education institutions can test the efficacy of their programs before large-scale implementation, ensuring that they deliver the best possible outcomes for students and establish a 'proof-of-concept' to share with other institutions. Additionally, building such programs with PaCE allows industry and post-secondary education to adapt programs as needs change, rather than building programs intended for generations to come. This avoids "sunk costs" and allows for further, ongoing investment in program development, refinement, and adaptation.

With the growing acceptance of Credit for Prior Learning, many of these programs can translate to additional credentialing via credit transfer including degree completion for the growing, "some college, no credential" population in California (~7 million people) and nation-wide (>40 million).[33] In Los Angeles County alone, more than 2.1 million individuals ≥25 years plan to pursue post-secondary education. These statistics spotlight a growing need to serve not only the needs of recent high school graduates, but also the professional and continuing education challenges facing incumbent and displaced workers. Talent pipelines provide a targeted way for higher education leaders to respond to anticipated declines in traditional enrollment due to declining birth rates during the Great Recession.

CONCLUSION AND RECOMMENDATIONS

Through implementing talent pipelines that respond to the unprecedented KSA gaps created by the 4IR, leaders in PaCE education can bolster relevance and competitiveness of their campuses by designing talent pipelines that add value to credit- and noncredit-based models. Talent pipelines can provide students with hands-on activities and experiences co-developed and administered by employers and educators. Unlike traditional internship or externship requirements for a degree, talent pipelines allow educators and employers to co-create training and curriculum that give students the tools, knowledge, and experience needed to be hirable candidates. Talent pipelines, unlike traditional internships, feature a structured onboarding process and a bidirectional relationship between the educational institution and industry and governmental employers.[34]

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[32] Peter Wiseman and Mia Juritzen, "University as Connector" How Universities Can Align Industry Needs and Student Demand Using Data," Nous Group, May 2023, https://nousgroup.com/insights/university-as-connector/.
[33] J. Causey et al., "Student Outcomes Annual Progress Report – Academic Year 2021/22," Some College, No Credential (Herndon, VA: National Student Clearinghouse, April 2023), https://nscresearchcenter.org/wp-content/uploads/SCNCReport2023.pdf.
[34] Reeb and Park, "Trade and Transportation Talent Pipeline Blueprints", pp. 3-17.

Additionally, the experience of talent pipelines can help learners better understand the industry and make more informed decisions about future careers.[35] Joint efforts between faculty and industry to construct talent pipelines provide an opportunity to build trust and understanding in an era where the value of post-secondary education has been called into question.[36] Engagement and dialog facilitate sharing the value of post-secondary education to employers and job seekers and better translation of learning outcomes into the language of skills and abilities with which employers are more familiar.[37] These relationships can also have benefits research.[38] Ultimately, talent pipelines can help higher educational institutions create a more well-rounded and comprehensive education experience that equips students for success in the workforce while addressing a broad array of community needs.

Those priorities are reflected in the Talent Pipeline Challenge launched by the Biden-Harris Administration in 2022. The national challenge, "Supporting Employer Investments in Equitable Workforce Development for Infrastructure Jobs," provided a common call to action for "training providers, unions, and other intermediaries, including labor-management skills programs, community colleges, industry associations, philanthropic organizations, and worker centers, to commit to:

- Partner with employers to create or scale skills training programs, coupled with wraparound services like transportation assistance and childcare, that will prepare workers for in-demand jobs.

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[35] *For a recent and thorough appraisal of students' perceptions regarding the relationship between majors and career paths, see:* John J .Conlon and Dev Patel, "What Jobs Come to Mind? Stereotypes about Fields of Study [Working Paper]", June 17, 2023, Accessed August 29, 2023, https://johnjconlon17.github.io/website/Conlon_Patel_stereotypes.pdf.

[36] Megan Brenan, "Americans' Confidence in Higher Education Down Sharply", *News - Gallup, Inc.*, July 11, 2023, Accessed August 29, 2023, https://news.gallup.com/poll/508352/americans-confidence-higher-education-down-sharply.aspx. *See also*: Sophie Nguyen, Rachel Fishman, and Olivia Cheche, *Varying Degrees 2023: New America's Seventh Annual Survey on Higher Education* (Washington, D.C.: New America, August 9, 2023, Accessed August 29, 2023): https://www.newamerica.org/education-policy/reports/varying-degrees-2023/. *Although 'value' has been questioned per the Gallup poll, many still see a degree credential as important to achieve personal and professional goals, see:* Ben Wildavsky, "Let's Stop Pretending College Degrees Don't Matter: Guest Essay." *New York Times* (August 21, 2023, sec. Opinion. ProQuest Global Newsstream): https://www.nytimes.com/2023/08/21/opinion/skills-based-hiring-college-degree-job-market-wage-premium.html.

[37] *This is particularly crucial given the rise in interest in 'skill based hiring' as highlighted in this article from the Harvard Business Review:* Joseph Fuller, Christina Langer, and Matt Sigelman, "Skills-Based Hiring Is on the Rise", *Harvard Business Review*, February 11, 2022, https://hbr.org/2022/02/skills-based-hiring-is-on-the-rise. *However, there is little indication of a movement to change hiring practices to align with this growing demand:* Elyse Ashburn, "Talk of Digital Credentials and Skills in Hiring Is Everywhere—but the Tech Isn't There yet", *Work Shift*, March 22, 2023, https://workshift.opencampusmedia.org/talk-of-skills-based-hiring-is-everywhere-but-the-tech-isnt-there-yet/; Sean Gallagher, Mark Leuba, Christopher Houston, and Emilee Trieckel, "Digital Credentials and Talent Acquisition Tech: Closing the Data Gap between Learning and Hiring" (Northeastern University: The Center for the Future of Higher Education and Talent Strategy, March 2023): https://cps.northeastern.edu/wp-content/uploads/2023/03/Digital_Credentials_Talent_Acquisition_Tech.pdf
This gap between rhetoric and action has led some to claim that skill-based hiring tropes are nothing but 'value signaling.' See: Ben Wildavsky, "Let's Stop Pretending College Degrees Don't Matter: Guest Essay", *New York Times*, August 21, 2023, sec. Opinion. ProQuest Global Newsstream, https://www.nytimes.com/2023/08/21/opinion/skills-based-hiring-college-degree-job-market-wage-premium.html.

[38] Michael M. Crow and William B. Dabars, *The Fifth Wave: The Evolution of American Higher Education*, Baltimore, MD: John Hopkins University Press, 2020, https://doi.org/10.1353/book.73164.

- Help recruit regional and local employers from infrastructure sectors into the Talent Pipeline Challenge.
- Work with employer partners to identify, recruit, and support women and workers of color so they will be employed in infrastructure jobs, including workers from communities with persistent poverty, and rural and Tribal communities.
- Provide grant funding for employer-training-provider partnerships and defer costs of advanced skills training, particularly for underserved workers.[39]

The Biden-Harris initiative reflects an increasing consensus that talent pipelines provide an integrated framework to invest in human workforce priorities in ways that directly address education and training gaps but also support services to ensure that emerging, incumbent, and displaced professionals can address basic life responsibilities while acquiring 4IR KSAs. Considered in this way, talent pipelines provide not only workforce development solutions but also a call to action for leaders in industry, government, and education to prioritize investments in human potential above investments in nonhuman capital that, if left unchecked, could lead to a world where humans matter less than profits, technological systems, and physical assets.

What follows is a series of recommendations for leaders in industry, government, and education to work together to break down institutional impediments that prevent thoughtful responses to 4IR KSA gaps. Many higher education reformers advocate a pivot from traditional curricula to modernized pedagogies that emphasize the in-demand skills of today's industries as they meet the challenges of the 4IR. The learning objectives identified in traditional curricula and modern pedagogies need not be at loggerheads. Across in-person, virtual, and hybrid instruction models, it has and will always be possible to integrate essential learning objectives from traditional and modernized pedagogies into one curriculum.

Recommendations

The pilot programs deployed by the authors revealed simple yet essential tactical requirements for successful talent-pipeline recruitment and implementation.

- Provide students with paid talent-pipeline opportunities.
- Recruit via word of mouth and social media.
- Conduct labor market analyses and related workforce services that allow PaCE professionals to identify and target occupational demands and career clusters to inform the development of talent pipelines and research and development collaborations that address local community needs.
- Create test beds for program development to respond promptly to employer and student needs.
- Support the development of online and hybrid credit and noncredit programs that are not bound by traditional academic calendars and formats.

[39] "FACT SHEET: The Biden-Harris Administration Launches the Talent Pipeline Challenge: Supporting Employer Investments in Equitable Workforce Development for Infrastructure Jobs," *The White House Briefing Room* (blog), June 17, 2023, https://www.whitehouse.gov/briefing-room/statements-releases/2022/06/17/fact-sheet-the-biden-harris-administration-launches-the-talent-pipeline-challenge-supporting-employer-investments-in-equitable-workforce-development-for-infrastructure-jobs/.

Re-engineering PaCE curricular development and programming that supports a range of talent-pipeline solutions will require policy revisions in government and education. The following recommendations will help guide PaCE leaders to develop sustainable talent pipelines that are more compatible with the unique challenges facing emerging, incumbent, and displaced professionals.

- Develop sustainable funding strategies with industry and governmental partners. The primary challenge for PaCE units serving as connectors or workforce intermediaries is financial. A reality for PaCE, and any other self-supporting unit, is that one-time funds can dry up—meaning talent-pipeline programs need diverse and ongoing investment from a broad group of stakeholders.
- Address communication and competitive pressures between PaCE units and traditional colleges. Lack of PaCE integration into campus infrastructure often creates competition with other campus units over resources and leadership of industry engagement. Furthermore, multiple points of access to programs undermine the university's ability to serve as an effective "connector" by creating confusion and lack of trust about institutional priorities. Thus, tangible benefits from talent pipelines must be communicated broadly to external stakeholders and internal campus partners.
- Revise historical, restrictive administrative and statutory barriers (e.g., supplanting, financial flexibility in the use of PaCE revenue, student enrollment restrictions) that prevent talent-pipeline implementation.
- Consider ways that Learning and Development can become a parallel priority in the design, development, implementation, and maintenance of new technological systems.
- Introduce policies that promote degree completion with modular stackable options, credit for prior learning, upskilling, reskilling, and alumni reengagement.
- Embed professional and continuing education in institutional academic missions and strategic plans.
- Standardize systems (e.g., information technology, data, student services, budget planning) that empower the university to develop a comprehensive view of students and community.
- Leverage the expertise that informs talent-pipeline formation to elevate PaCE within colleges as an intellectual (not just logistical) partner in education and community engagement.
- Serve as a hub for lifelong learning.
- Use insights from the longitudinal analysis of the Transportation Technology Tournament in this report to design and implement a consortium-led talent pipeline.

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APPENDIX A: FLYERS, TABLES, AND FIGURES

GANNETT FLEMING

CITT CENTER FOR INTERNATIONAL TRADE AND TRANSPORTATION CSULB

COLLEGE OF ENGINEERING

Paid Summer Internship at Gannett Fleming:

Are you interested in the future of Intelligent Transportation Systems (ITS)?

Develop KSAs for a Game-Changing Industry

The implementation of ITS smart mobility infrastructure in communities across the country is driving demand for engineering graduates with the knowledge, skills, and abilities (KSAs) associated with these transformational technologies. The ITS Engineering Talent Pipeline at California State University, Long Beach gives interns a rare opportunity to work with ITS experts on a range of innovative projects and real-world test beds.

About the ITS Engineering Talent Pipeline

Selected CSULB engineering junior and senior students will participate in talent-pipeline activities that will prepare them for a paid summer internship at Gannett Fleming's Irvine offices. Gannett Fleming is a pioneer of architectural, engineering, and construction innovations that support resiliency and sustainability in our rapidly changing world.

Requirements

- ☑ Must be a CSULB Engineering Student in your third or fourth year of undergraduate studies or pursuing a graduate degree at CSULB
- ☑ Strong critical thinking and qualitative/quantitative skills
- ☑ Interest in pursuing a career in ITS
- ☑ Aptitude and willingness to learn about transformational technologies

GANNETT FLEMING

About Gannet Fleming

CITT CENTER FOR INTERNATIONAL TRADE AND TRANSPORTATION CSULB

About CITT

The ITS Engineering Talent Pipeline is led by CITT and Gannett Fleming, in partnership with CSULB's Colleges of Engineering, Continuing and Professional Education, and the Undergraduate Research Opportunity Program.

Apply Now

Jet Propulsion Laboratory
California Institute of Technology

CITT
CENTER FOR INTERNATIONAL TRADE AND TRANSPORTATION
CSULB

COLLEGE OF
Natural Sciences and Mathematics

Summer Internship at JPL:

Are you interested in the future of data science and satellite technology?

Develop KSAs for a Game-Changing Industry

Breakthroughs in satellite technology and data science are driving demand for college graduates with knowledge, skills, and abilities (KSAs) associated with computer coding, data analysis, and quantitative reasoning. The Data Science Talent Pipeline at California State University, Long Beach gives students a rare opportunity to work with JPL scientists on a range of innovative projects using satellite data.

About the Data Science Talent Pipeline

CSULB students from any major will participate in a workshop that, for some, might lead to a summer (2023) internship at JPL. Students who participate in both days of the on-campus workshop scheduled on April 7-8 will earn $200.

Requirements

- ☑ Must be a CSULB student eligible to work in the U.S. and willing to work onsite at the Jet Propulsion Laboratory in Pasadena
- ☑ Strong critical thinking and qualitative/quantitative skills
- ☑ Interest in data science and coding
- ☑ Aptitude and willingness to learn about transformational technologies

Jet Propulsion Laboratory
California Institute of Technology
About JPL Internships

CITT
CENTER FOR INTERNATIONAL TRADE AND TRANSPORTATION
CSULB
About CITT

The Data Science Talent Pipeline is led by the CSULB College of Natural Sciences and Mathematics in partnership with CITT and the Jet Propulsion Laboratory.

Apply Now

Table 1. Collaboration between CSUs and Local Industry Partners

Common Agenda:	Strategic networks of PaCE units on CSU campuses, industry partners, and government agencies establish common agendas to implement talent-pipeline strategies in the form of short-term programming, certification programs, etc. as a solution for targeting transformational skills building in the face of a rapidly changing work landscape.
Shared Measurement:	All partners involved agree to collect data and share results across all stages of talent-pipeline planning and implementation to assess the effectiveness of the programming and each partners' involvement.
Mutually Reinforcing Activities:	All partners agree to play a distinct role in talent-pipeline planning. CSU partners agree to be the backbone support and facilitate educational/training programs; industry partners agree to provide experts and consultants who can lead the conversation on in-demand KSAs, cast the vision for the selected programming/work of the talent pipelines, and refer instructors for the CSUs; government agencies can provide economic support and resources.
Continuous Communication:	All partners agree to scheduled meetings and a schedule of events/actions/etc. that are required for successful cross-sector collaboration and planned execution.
Backbone Support:	CSU partners will serve as the facilitators and managers of this collective impact and will primarily be responsible for convening partners to initiate and coordinate participation from all other partners

Source: Reeb and Park, "Trade and Transportation Talent Pipeline Blueprints", p. 18. Adapted from: Fay Hanleybrown, John Kania, and Mark Kramer, "Channeling Change: Making Collective Impact Work," *Stanford Social Innovation Review*, 2012, https://doi.org/10.48558/2T4M-ZR69.

APPENDIX B: SURVEYS

Item 1: Stakeholder Survey

The following is a condensed collection of the survey questions posed to stakeholders. Graphics were removed and formatting was adjusted and simplified.

1. I ____ university-industry partnerships.
    a. Strongly Oppose
    b. Oppose
    c. Support
    d. Strongly Support
2. How long have you been part of the CSULB community?
    a. Less than 1 year
    b. 1-5 years
    c. 5-10 years
    d. 10-15 years
    e. 15-20 years
    f. More than 20 years
    g. Nonapplicable: I am not a member of the CSULB community
3. How long have you been in your current role at CSULB?
    a. Less than 1 year
    b. 1-5 years
    c. 5-10 years
    d. 10-15 years
    e. 15-20 years
    f. More than 20 years
4. What are **your** current areas of interest? Select as many as are applicable
    a. Transportation & Mobility
    b. First Principles Engineering
    c. Data Science
    d. Community Health & Wellness
    e. Sustainable & Resilient Ecosystems
    f. Art & Innovation
    g. Designing Cultures of Continuous Improvement
    h. Other (please describe)
5. In which of the following areas do you believe **CSULB** has the most to offer Research and Workforce Development? Select as many as you would like
    a. Transportation & Mobility
    b. First Principles Engineering
    c. Data Science
    d. Community Health & Wellness
    e. Sustainable & Resilient Ecosystems
    f. Art & Innovation

   g. Designing Cultures of Continuous Improvement
   h. Other (please describe)
6. What are your top three priorities when mentoring undergraduate and/or graduate students regarding professional development?
   a. Formal Professionalization (resume or interview coaching, etc.)
   b. Promoting Experiential Learning Opportunities (such as Internships)
   c. Over-and-Above Academic Activities/Opportunities (Conferences, Research Assistantships, etc.)
   d. Providing Guidance Concerning Further Education (Graduate School, Certifications).
   e. Providing Professional Contact Information (i.e., contacts with relevant industry professionals, informal meetings with likeminded career professionals, etc.)
   f. Other (please describe) _____
   g. I do not have experience mentoring students
7. Please gauge your agreement or disagreement with the following statements21F[40]
   a. Students graduating from my department are well-prepared for research or research-oriented careers.
   b. The knowledge and skills attained/developed by students who major or minor in my department are underappreciated or unrecognized by industry professionals.
   c. CSULB is prepared for demographic changes in the composition of the student body (i.e., increasing number returning students without a degree, first-time students who work full-time, etc.).
   d. Students in my department are aware of career paths that will be a "good fit" for the knowledge, skills, and abilities they develop.
   e. Current open-opportunity professional guidance events and activities – such as guest speakers or career fairs – are beneficial for CSULB students.
8. How do you believe a Research & Development Gateway might best benefit your students? Select as many options as you would like
   a. Career Exploration
   b. Professional Development (developing connections with professionals in field of choice)
   c. Supplementing traditional classroom education (providing "real world" context unavailable in a classroom, etc.)
   d. Complementing traditional classroom education (i.e., enhancing classroom participation)
   e. Research Experience
   f. Career Motivation
   g. None of these options. I do not believe that a Research & Development Gateway would benefit my students. (Please explain your reasoning in the dropdown box below)
9. Please gauge your agreement or disagreement with the following statements22F[41]

[40] Respondents selected their answers on a Likert scale: Strongly disagree, Disagree, Neither agree nor disagree, Somewhat agree, Strongly agree.

[41] Respondents selected their answers on a Likert scale: Strongly disagree, Disagree, Neither agree nor disagree, Somewhat agree, Strongly agree.

   a. Industry Talent Pipeline "bootcamps" or training sessions ought to be open to any student, regardless of degree path. For example, a Fine Arts student ought to have an equal opportunity to enroll in a funded coding language program.
   b. Data Science, the study of data to extract meaningful insights, is a research tool used across disciplines. For example, Data Science can be deployed by researchers in the fields of biology, healthcare, marketing, and many others.
   c. The scholarship of trade and transportation is multidisciplinary, in that it benefits from the contributions of researchers with backgrounds in a variety of fields (including science, technology, engineering, mathematics, liberal arts, and more).
10. As colleges and universities work to better partner with industry, the approach is often fragmented between different departments and sectors of the institution. How could CSULB best ensure that efforts are complementary rather than competitive?
11. What problems faced by the community of Long Beach could be addressed by University-Industry innovations?
12. As colleges and universities across the country work to better partner with industry, the approach is often fragmented which leads to counterproductive "turf wars" between different departments and sectors of the university. How could CSULB best ensure that efforts are complementary rather than competitive?
13. Are there any other questions you would like to ask or comments you would like to provide?

Item 2: JPL Pre-Workshop Survey

The following is a condensed collection of the survey questions posed to JPL workshop participants prior to their participation in the workshop. Graphics were removed and formatting was adjusted and simplified.

1. What or who motivated you to participate in the workshop? How did you hear about this opportunity?
2. How would you define Data Science?
3. What do you think are common uses for the satellite data collected by research organizations like JPL? In other words, what is the value or purpose of the data collected by satellites orbiting the earth?
4. Can you tell us some ways (if any) that you might interact with satellite data on a daily basis?
5. Some of the projects and exploratory research carried out by JPL will eventually have applications for commercial, government and military systems. Are there any important benefits that derive from the research conducted by JPL? Are there any important benefits that derive from the research conducted by JPL? Are there any moral or ethical concerns that may be raised by the transformational technologies that this research develops?
6. Who do you think are key stakeholders in the development and deployment of advanced satellite technologies and the data collected by these technologies?
7. What knowledge, skills, or abilities do you want to develop by participating in this workshop? What do you think it offers you education and/or career development?

Item 3: JPL Post-Workshop Survey

The following is a condensed collection of the survey questions posed to JPL workshop participants after their participation in the workshop. Graphics were removed and formatting was adjusted and simplified.

1. Is there anything that you learned or experienced during the workshop that surprised you?
2. How would you define Data Science? Do you think your definition has changed much (if at all) because of this workshop?
3. What do you think are common uses for the satellite data collected by research organizations like JPL? In other words, what is the value or purpose of the data collected by satellites orbiting the Earth?
4. Can you tell us some ways (if any) that you might interact with satellite data on a daily basis?
5. Some of the projects and exploratory research carried out by JPL will eventually have applications for commercial, government and military systems. Are there any important benefits that derive from the research conducted by JPL? Are there any moral or ethical concerns that may be raised by the transformational technologies that this research develops?
6. Who do you think are key stakeholders in the development and deployment of advanced satellite technologies and the data collected by these technologies?
7. Did you develop any new areas of knowledge, skills, or abilities by participating in this workshop? What value do *you* think it has offered your education and/or career development?
8. During your time as a college student, there are many different career and professional development opportunities offered by the college, such as internships, guest speakers, job fairs, and so on. How do you think this workshop compares to your experiences with other career and professional development opportunities offered by the college?

APPENDIX C: PIPELINE PARTICIPANT RESPONSES

Students who participated in the Gannett Fleming pipeline were asked to briefly reflect on their professional interests and the ITS modules they studied. Slight modifications to formatting were made to anonymize students. Minor typos or other grammatical errors were corrected.

Student A: B.A. in Business Economics with minor in Comparative World Literature

For the Gannett Fleming summer internship, I would like to focus on the development and implementation of autonomous vehicles. When reviewing the ITS modules, this topic stood out as the most fascinating of the bunch to me. The third module, titled "Automation in Bus Rapid Transit", was the one that specifically piqued my interest. Previously, I was not aware of the implementation of autonomy in rapid transit bus systems, so it was very interesting to learn about. The benefits of autonomous vehicles, whether being used for transit systems or personal vehicles, could be revolutionary given the potential to reduce congestion and improve safety. Higher adoption of autonomous vehicles would lead to a safer, more efficient future, and for that reason I would love to contribute to the emerging field.

Additionally, I am interested in city planning and environmental damage prevention. Transportation and city planning go hand-in-hand, relying on each other to create an efficient community. I would like to help increase this efficiency through the use of my economic and writing-based skill set, researching problems and solutions and conducting relevant analysis. As for my interest in the environmental field, I believe it is an extremely important factor that needs to be properly thought out before going through with any future projects. To me, it is important to find the balance between solutions that are cost-effective and environmentally friendly, combining the two to yield the most efficient outcome.

I am excited to be on an ITS team and contribute to the problem-solving tasks to the best of my abilities. I believe I have what it takes to help solve issues related to privacy rights, local and state regulation, and raising capital for projects. My unique skill set, combined with the skill sets of others on my team, can help clear a path for the future of ITS.

Student B: B.S. in Civil Engineering with a focus on transportation systems

We are living in a world where things are changing rapidly. To keep up with the arising innovations such as AI and data collection, I believe we need to have a goal that keeps us motivated. My goal is to understand a little bit more about ITS, get familiar with the new technologies, new organization terms, be able to identify which technologies are going to stay, and how we can utilize them to improve our transportation system.

Again, during my internship, I want to focus on exploring and understanding different technologies and strategies that can be applied to new ITS implementation. One area of ITS that interests me is the concept of smart cities. As you may know, traffic congestion and inefficient transportation systems are major challenges faced by modern cities. These problems are caused by increasing population density and [an increasing reliance] on private vehicles. Smart cities are all about using new technologies and data to tackle these issues. It helps reduce traffic congestion, and create more sustainable, efficient, and smart modern cities.

Another area that has caught my attention is automated bus rapid transit (ABRT). Traditional bus rapid transit (BRT) systems face limitations in terms of operational efficiency, reliability, limited flexibility in

route planning and scheduling, and passenger experience. ABRT solves most of these problems by using smart sensors, artificial intelligence, and connectivity to create a faster and more efficient public transportation system. I believe that by adopting smart city principles and ABRT, we can address some of the challenges we face today, such as traffic congestion, carbon emission, pollution, and inadequate infrastructure.

In addition to building my technical skills, I also want to enhance my communication skills. Effective communication is essential in any professional setting, and I want to improve my ability to articulate ideas, collaborate with team members, and present my work clearly and confidently.
At the end of my internship, I am hoping to find my capabilities and potential within the field of intelligent transportation systems and gain valuable experience.

Student C: M.S. in Computer Science, particular interest in artificial intelligence and machine learning

Objective: As a part of the main objective of the case study, I was supposed to go through the ITS PCB modules and undergo the pre and post surveys to understand what I gain from the modules vs what I already knew.
Key Elements: Key elements being the data received under transportation and the challenge about how the ITS can contribute to improved transportation and trade systems.

Summary:

- The introductory module has been explained very well with examples and testimonies at various place to serve as [evidence for the claims made]
- The inclusion of a video and real data is great but some words need to be rephrased
- For the planning module, there were certain grammatical errors. Great visuals were included but captions and explanation needs to be given in order to make those visuals clear
- I loved the inclusion of Bus Rapid Transit in the modules as it is one of the best examples to show the advancement in transportation. [However,] I feel a couple of other example modules like autonomous driving or connected and communicating vehicles could be equally interesting and intriguing
- For the travel time module, there was much statistical information and formulae, which was necessary but a few example questions could have made the topics clearer
- I felt that data driven decisions module was the most effective and important one as it holds a great importance in the analysis and decision making for any intelligent systems
- I loved the visuals and explanations on the CMS module
- The ITS architecture module was the least effective in terms of deliverables for me as the architecture was mentioned but just with the diagram and was not clearly explained with steps.
- The architecture of any system is an integral part for its proper undertaking but it is not clearly [explained by] the module which can be improved

Suggestions for future iterations of the ITS module:

- In addition to the existing module, I feel that including one about sustainability and environmental impacts [would be justified]. Highlight how ITS can contribute to sustainable transportation

practices by reducing congestion, optimizing fuel consumption, and promoting alternative modes of transport.

- I also feel like exploring the latest trends and emerging technologies in ITS, such as 5G connectivity, edge computing, artificial intelligence, and blockchain applications can arise a sense of curiosity in whoever is reading the documents and thus should be included.

APPENDIX D: TALENT PIPELINE LAUNCH EVENT (NOVEMBER 16, 2022)

Title: *Trade and Transportation Talent Pipeline Blueprints: Building Industry-Driven Talent Pipelines in Colleges of Continuing and Professional Education*

Presenters:

- Chris Swarat, Ph.D., *Dean, College of Professional and Continuing Education at California State University, Long Beach*
- Eric Rensel, *Vice President, Strategic Initiatives, Gannett Fleming*
- Bill Panos, *Senior Advisor and Vice President, Gannett Fleming*
- Adam Hopps, *Technical Services and Communications, National Operations Center of Excellence*
- Mike Chesney, *Vice President, Roadway Business Group Area Manager for Southern California, Gannett Fleming*
- Gwen Shaffer, Ph.D., *Associate Professor, CSULB; Chair, City of Long Beach Technology & Innovation* Commission
- Hilary Nixon, Ph.D., *Deputy Executive Director, Mineta Transportation Institute, San Jose State University*
- Tyler Reeb, Ph.D., *Director of Research and Workforce Development, Center for International Trade and Transportation (CITT)*
- Stacey Park, *Research Associate, Center for International Trade and Transportation (CITT); PhD Student, English Language and Literature, Claremont Graduate University*

Agenda:

- Introduction
    - Tyler Reeb: What's the ROI on Talent Pipelines in the CSU system?
    - Chris Swarat: Why university-industry talent pipelines make sense for Colleges of Continuing and Professional Education?
- Industry Perspective
    - Eric Rensel: Major industry needs and why Gannett Fleming supports the ITS Engineering Talent Pipeline Pilot at CSULB.
    - Bill Panos: The role of state and federal government in supporting talent pipelines. How can talent pipelines help state departments of transportation address workforce challenges?
    - Adam Hopps: Why talent pipelines are a top priority for the National Operations Center of Excellence. Scaling the ITS pilot nationally.
- Talent Pipeline Methodology
    - Tyler Reeb: Single-employer talent pipeline model
    - Tyler Reeb: Consortium talent pipeline model
- The ITS Engineering Talent Pipeline Pilot at CSULB
    - Tyler Reeb: ITS Talent Pipeline Pilot Curriculum
    - Eric Rensel: Paid Summer Internships
    - Mike Chesney: What are the key ingredients for a successful engineering talent pipeline?
    - Gwen Shaffer: Learning While Doing: An ITS Real-World Learning Exercise
- Establish a university-industry talent pipeline on your campus.

    - Hillary Nixon: Applying for California State University Transportation Consortium (CSUTC) grant support to establish university-industry talent-pipeline partnerships.
- Discussion: Questions, Comments and Next Steps