Work in Progress: Studying How Engineering Research Internships Affect Community College Students' Interest in and Intent to Complete Engineering Bachelor's Degrees

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To facilitate transfer pathways for community college students wanting to pursue engineering careers, the University of Colorado Boulder launched an engineering internship program in collaboration with the University of Colorado Denver, the Community Colleges of Denver and Aurora, the National Renewable Energy Laboratory (NREL), Lockheed Martin, and others. Under the award, three additional community colleges will implement the model in future years contributing students to the target number of 60 internship participants each summer of the project. When it concludes, this six-year project will have supported ~300 community college students from five Denver-area community colleges in 10-week (at full-time), paid, engineering-research experiences. This paper explores the feedback collected from participants during the first year of the internship program to understand how students' experiences may be affecting their interest in continuing their engineering pursuits.

Overview

The *Engineering Momentum* project, (formerly the Denver-Metro Engineering Consortium), funded by the US Department of Defense[1] is a pathways model designed to introduce underrepresented community college students to engineering bachelor's degree programs and entry into the engineering workforce. As part of this six-year-long program to encourage students into and through a pathway that prepares them for an engineering career, the Engineering Momentum initiative incorporates multiple programs that foster engineering awareness, including a robust summer internship which allows students to gain valuable engineering research experience. The program anticipates 425 students will participate in Engineering Momentum throughout the six years of the grant (see Table 1), with a subset of ~300 of these students participating in a summer internship.

Engineering Momentum will broaden participation of underrepresented students by developing clear, accessible, and supported pathways to two-year associate degrees, to internships with STEM employers, to transfer opportunities to four-year research institutions and subsequent bachelor's (BS) degree attainment, and to opportunities to join the defense workforce with high-wage engineering career opportunities. The project seeks to broaden participation through a five-stage approach (see Figure 1). As the Engineering Momentum project is implemented at partner campuses and continues to grow, it has the potential to close the gap in equity and access for academically underserved students in Denver, Colorado's metropolitan area and can be adopted in other states to replicate.

In this novel approach, we create a collective comprised of faculty, recruiters, advisers, students, and employers to implement "on-the-ground" structures and practices that support the increase of underrepresented students' completion of engineering degrees and entry into the defense workforce. Our consortium facilitates collaboration among regional stakeholders to share expertise

[1] This work relates to Department of Defense award (HCQ00342220005) issued by the Office of Naval Research. The United States Government has a royalty-free license throughout the world in all copyrightable material contained herein.

and solutions across geographically proximate community colleges and universities, and we embrace recommendations from regional industry and national laboratories to improve capacity for them to hire local talent.

Background

This project leverages best practices learned through the *STEM Core Expansion Alliance,* a National Science Foundation-funded Eddie Bernice Johnson INCLUDES Initiative, which has successfully transitioned community college learners from developmental math to calculus readiness within one year. Both the Engineering Momentum co-PI and the backbone organization are integral collaborators with the STEM Core Expansion Alliance.

The STEM Core model transforms students from developmental math to calculus readiness in one year, such that they may enter the STEM workforce or transfer into four-year BS programs. Through leveraging the NSF INCLUDES Alliance awards (NSF #1834628 and #1834608), Engineering Momentum builds on the success and knowledge gained from the current STEM Core Expansion initiative by developing a sustainable and replicable program to broaden participation in STEM, both in education programs and the workplace. Engineering Momentum also includes the implementation of the STEM Core model at each their five community college partners.

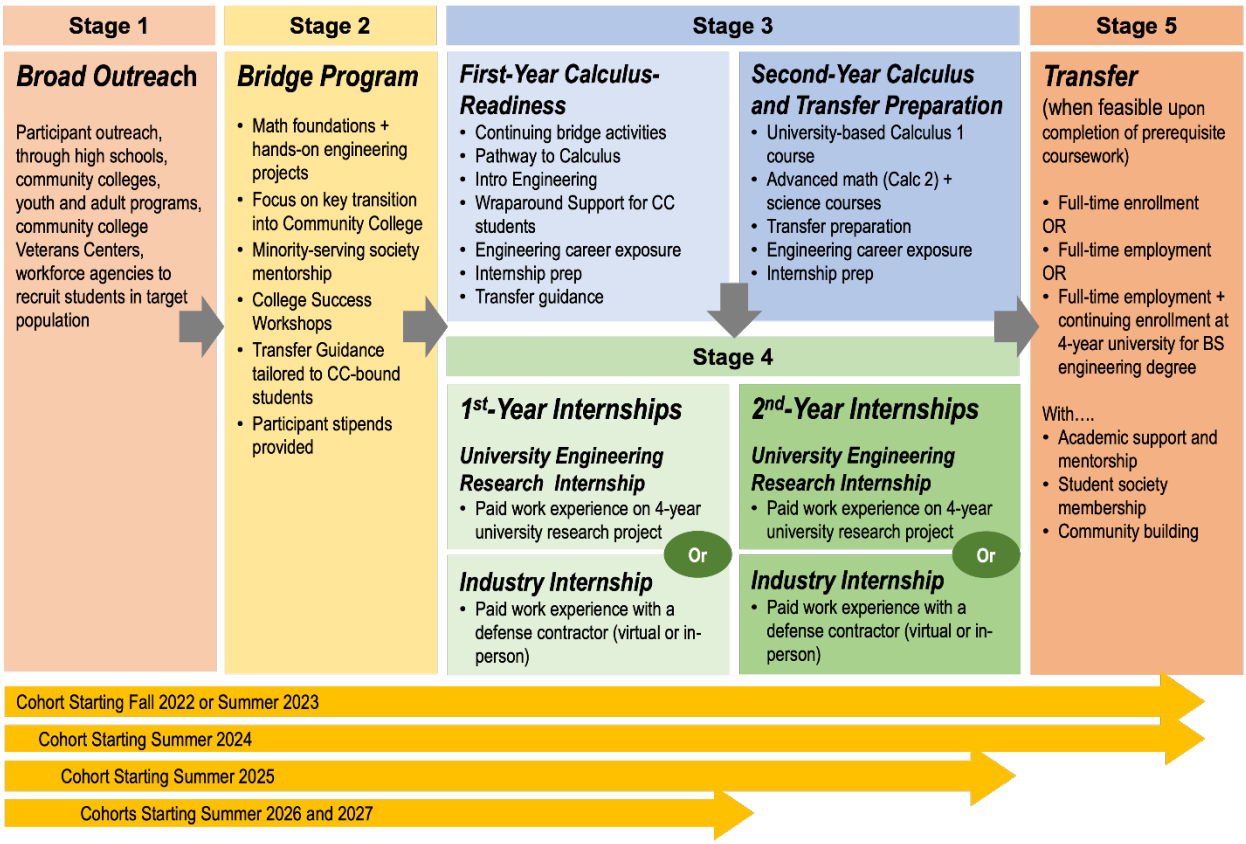

Figure 1. The Engineering Momentum pathways project.

The initial three-year program design and intervention activities (Phase 1) will include five cohorts of approximately 25 students each (125 students total). During Phase 2, years 4-6, the project plans

to scale to three additional colleges and include 75 additional students each for years 5-6 (Table 1), for a total of 425 students over six years (17 cohorts of 25 students each).

Table 1. Community college student impact

School	Years of project	No. of student cohorts	No. of students p/cohort	Total students
Community College of Aurora	1-6	6	25	150
Community College of Denver[1]	1-6	5	25	125
Red Rocks Community College[2]	4-6	2	25	50
Front Range Community College[2]	4-6	2	25	50
Arapahoe Community College[2]	4-6	2	25	50
Totals		**17**		**425**

[1] Year 1 is a planning year for the Community College of Denver.

[2] Years 4-6 (phase 2) include three "optional" years for scaling, with year 4 being a planning year for three new colleges. Two cohorts of ~25 students, at each new college, will be supported through Engineering Momentum.

A Focus on Transfer

Engineering Momentum aims to deploy a multi-year pathway model to nurture community college-to-university engineering transfer, first locally and then replicable nationally (Figure 1). It is projected that more than 400 students will be served who might not have otherwise pursued engineering for their future.

Transfer pathways offers strong potential to increase engineering degree attainment, particularly among students who are first generation to college, experiencing low income, of racially/ethnically minoritized backgrounds, and/or who need the support of smaller classrooms to develop academic confidence and skills. The potential for the transfer pathway has not been fulfilled [1]-[19], despite more than 30 years of focus across the U.S. We seek to use research-based practices, build strong partnerships/pathways, and use evidence from lessons learned to refine our program, share what we have learned, and improve the community college avenue into the engineering profession.

Internship Model

Traditional undergraduate engineering internships occur after students' junior year at university. This requires students to complete advanced calculus, physics, and other engineering and science courses before ever connecting classroom topics to real-world applications in research and/or industry. Additionally, most community college students work for income, although not in technical or engineering settings. Placing calculus-ready Engineering Momentum participants into paid summer internships during their first year helps students in critical ways—providing summer income, reinforcing and applying academic concepts to real-world applications, and practicing specific engineering disciplines. Engineering Momentum participants can apply for two types of paid summer engineering internships—industry internships (some of which are with defense employers) and research internships based at the University of Colorado Boulder and the University of Colorado Denver.

The project includes six years' funding to directly support up to 307 STEM Core-qualified community college students to participate in paid internships. While the project anticipates supporting 425 students over the course of both project phases, not all students will be qualified for an internship due to the timing of their calculus-readiness and/or their academic preparation in other relevant courses. We want students to choose this internship to gain experience in meaningful pre-professional work and to benefit more financially than having an unskilled labor or service/retail job. However, Colorado's high cost of living posed budget challenges as we implemented the project as originally proposed. To provide stipends competitive with Denver's 2023 minimum hourly wage of $17.29[2], we scheduled internships to be 35 hours a week—rather than the traditional 40-hour full-time work week. Not only did this mean that students received more money than the local minimum wage, but those who had a second job or family obligations had greater flexibility during the 10-week commitment.

Goals of the internship include offering early-career college students:

- real-world, discipline-specific experience through hands-on engineering,
- mentoring from faculty, graduate students, and/or industry experts,
- a competitive salary and living stipend, and
- a vision and incentive to persist, transfer, and complete a B.S. in engineering.

With Department of Defense funding, community college students applied to participate in 10-week, research-intensive internships, either at the University of Colorado Boulder, the University of Colorado Denver, or with an industry partner. Students who applied for internships through Engineering Momentum were provided the opportunity to engage in mock interviews with immediate feedback, resumé review, and application guidance, offered in conjunction with the community colleges' Career Services or Growth Sector (the backbone organization). During the competitive application process, project leadership interviewed students to assess their interests and determine whether they preferred a university or industry internship. Based on the interviews and a review of their qualifications (Table 2), students received initial placement—or, unfortunately, notice that they had not been selected.

Table 2. Internship Criteria

Curriculum Pathway	GPA[2]	Math Preparation	Prior or Current Coursework	500-Word Essay/ Application
STEM Core[1]	2.75	Calculus-readiness	engineering, engineering technology, physics, computer science	Students described their interest in engineering and desire to earn a BS in engineering; they also could discuss any inconsistencies in their academic history.

[1] The STEM Core supports developmental math students from populations historically underrepresented in engineering, including women, Veterans, and Black, Hispanic, Native American and first-generation college students.

[2] In some cases, students with a lower GPA were considered if their essay effectively addressed a drop in their grades due to unusual circumstances outside their control.

[2] For reference, the Denver City and County of Denver minimum hourly wage was $15.87 when the Engineering Momentum project was proposed in early 2022; currently, in 2024, the rate has further increased to $18.29.

Two Internship Options

University Research Internships—Students who complete requisite coursework from partner community colleges are eligible for summer internships at University of Colorado Boulder and University of Colorado Denver. These 10-week experiences allow interns to participate in state-of-the-art defense-related research led by university engineering faculty. Interns work alongside the faculty, graduate, and undergraduate students, as well as other members of the research labs to gain valuable knowledge and experience about a specific area of research, as well as its application in a specific application of that discipline. Areas of research include: additive manufacturing and advanced materials; artificial intelligence and machine learning; autonomy and robotics; cybersecurity; electromagnetics, communications, RF electronics, and 5G; microelectronics; power and energy systems; chemically responsive liquid crystal polymer development; broadband inherent linear transmitters; high-accuracy (1%) measurements in propulsion and hypersonic systems; emergent capability in dynamic human-robot teams; thermal protection of hypersonic vehicles; and topological acoustics, among others. In addition to gaining workplace and research experience, participants learn about the host university and develop social, educational, and professional contacts to help them navigate transfer and then entry to the workforce.

Defense-related Industry Internships—Engineering Momentum leverages existing relationships with defense industry employers currently hosting community college interns through the NSF STEM Core Expansion INCLUDES Alliance project, including multiple federal energy laboratories (National Renewable Energy Laboratory, Livermore, Sandia, Los Alamos, Argonne), NASA Centers (Goddard, JPL), and Lockheed Martin. Lockheed Martin, who has a site location in southwest Denver and also offers remote internships with researchers at other locations, aims to eventually support up to 12 internships per year as part of their partnership with the STEM Core Expansion and will also make available pathways to part-time engineering aide positions in Colorado. Once hired, Engineering Momentum participants are eligible for up to $7,000 tuition benefits p/year. Sandia National Laboratories is planning to host interns in the growing area of Quantum Information Science, which is a growing area of focus for the region. All INCLUDES partner internships are available to Engineering Momentum applicants should they desire to apply for an internship out of state.

Leveraging Capacity: Pilot-Year Internships and Partnerships

In place since 2016, the Summer Program for Undergraduate Research (SPUR), an existing summer internship opportunity for University of Colorado Boulder's engineering college, supports undergraduate students with college resources and matching funds from faculty research awards. In its inaugural year, SPUR hosted 10 campus undergraduates and has successfully supported 362 students to date. As the University of Colorado Boulder began to focus on transfer as an important pathway for its student population, SPUR became interested in partnering with Engineering Momentum to offer summer internships to both university students and early-stage community college students interested in engineering.

Engineering Momentum valued a collaboration with SPUR—benefitting from its expertise and track record of opening new pathways for qualified interns—which would allow community college students to enter the program. Engineering Momentum placed 20 community college students in 2023 through SPUR. Another 10 students interned at the University of Colorado Denver, and five community college students interned at Lockheed Martin.

Engineering Momentum research internships included mentoring from the professor, graduate students, and peer-to-peer collaboration between two- and four-year students. In 2023, participating faculty, labs, and industry partners spanned eight unique engineering disciplines at two four-year institutions, and two industry sites to offer 35 community college students hands-on engineering research experiences (see Table 3).

Table 3. 2023 Internship Summary

Project	**Engineering Department/ Program**	**# Faculty Mentors # Grad/Other**
University of Colorado Boulder		
Design, fabrication, and assemble of FPS/GNSS receivers/enclosures	Aerospace	1 Faculty
Great Lunar Expedition for Everyone (GLEE) *	Aerospace	2 Faculty
Modeling human cognitive state to improve human-autonomy teaming for deep space	Aerospace	1 Faculty 1 Grad
Software engineering for space habitat autonomous systems	Aerospace	1 Faculty 1 Grad
Rewiring water electrolysis for renewable chemicals and hydrogen	Chemical & Biological	1 Faculty 1 Grad
Mitigating indoor air quality in local public schools #	Civil, Environmental & Architectural	1 Faculty 1 Grad /1 Other
Assessing the accuracy vs. cost of different material models in composites	Civil, Environmental & Architectural	1 Faculty 1 Grad
Integrating large language models with program verification	Computer Science	2 Faculty
Scientific computing libraries in rust	Computer Science	1 Faculty 1 Grad
Design and construction of an instrument droid	Electrical, Computer & Energy	2 Faculty
Establishing a standard security benchmark suite	Electrical, Computer & Energy	1 Faculty 1 Grad
Optimization of throughput and aggregate analysis for millikelvin single-photon materials loss measurements in the microwave regime	Electrical, Computer & Energy	1 Faculty 1 Grad
Synbiohub plugins for sequence annotation and visualization	Electrical, Computer & Energy	1 Faculty 1 Grad
3D printing novel static mixer elements	Mechanical	1 Faculty 1 Grad
Impact of mechanical forces on metastatic tumors in an engineered bone scaffold	Mechanical	1 Faculty 1 Grad
Informing school decision-making during wildfire events: evaluation of indoor pm2.5 exposures and associated health impacts in children	Mechanical	2 Faculty
Mitigating Wildfire Smoke Exposure in Denver Schools	Mechanical	2 Faculty 1 Grad
Optical cell design for high resolution spectroscopy	Mechanical	1 Faculty

in the mid-infrared region		1 Grad
University of Colorado Denver		
Deployment of Multi-Day Manual Wheelchair Activity Monitoring Sensor Platforms	Bioengineering	1 Faculty
Alternative Wood-based Materials and Methods for Residential Construction	Civil	1 Faculty 1 Grad
Testing of Reinforced Concrete Members with Advanced Composite Material	Civil	1 Faculty
Alternative Wood-based Materials and Methods for Residential Construction	Computer	1 Faculty
Technology Customer Discovery	Computer	1 Faculty
Data Bias Impact in Privacy-aware Data-blind ML Models	Cybersecurity	1 Faculty
Linux SBC API Function Development	Electrical	1 Faculty
Magnetic Materials Research	Electrical	1 Faculty 1 Grad
Radio Observations and Data Analysis for Space Weather	Electrical	1 Faculty 1 Grad / 1 Other
Realization of Energyshed Through Networked Microgrids	Electrical	1 Faculty 1 Grad
Lockheed Martin		
5 community college students	Computer Science	5 Research Leads 5 Assoc Engineers
National Renewable Energy Laboratory ^		
2 community college students	Electrical	2 Research Leads

* Project hosted 3 community college interns.
# Two students were placed on this project; one student left their internship in the first week due to unreconcilable religious beliefs.
^ Students funded by the National Science Foundation.

Case Study

We quickly learned that students in our target population led complex lives that required the Engineering Momentum leadership team to revise our prior beliefs about what it means to be a "good student." A key shift for us was to be flexible with deadlines, grades, perceptions of academic "effort." A prime example was Manuel,[3] who had moved homes every few weeks during the first semester of school. Not surprisingly, his grades dropped when their laptop vanished between moves, which led to multiple missed class assignments. When our internship application deadline grew near, Manuel was not ready. However, Manuel, with the help of his STEM advisor, wrote a compelling essay describing that he was falling short in school due to his turbulent housing conditions. The essay continued, though. Manuel stated that the sun was shining on him because a fabulous mentor had begun helping him to gain greater stability to focus on school. With that support, Manuel was accepted into an internship at the University of Colorado Boulder, found a

[3] Name changed to protect student identity.

full-time job there, transferred from their community college, and is steadily taking courses to complete his BS degree.

Prior thinking on expectations for this target population almost allowed Manuel to slip through the cracks. Fortunately, the Engineering Momentum team recognized and managed any deficit mindset on its part and supported Manual to enter a pathway to their future career.

Study Demographics

During the 2023 pilot internship program, 48 students from four community colleges applied for internships. Thirty-five students were placed in internships: twenty at the University of Colorado Boulder, ten at the University of Colorado Denver, and five at Lockheed Martin. Table 4 shows the demographics of the students. Note: due to funding requirements, all students listed are either US citizens (n=33) or Permanent Residents (n=2).

Of the 35 students placed in internships, two left the program: one in the second week of the program for religious reasons, and another in the 8th week in response to the call for all armed forces to activate. As of this writing, many of the 2023 interns have reapplied for an internship during summer 2024.

Table 4. 2023 Internship Study Demographics (non-unique identifiers, self-reported data)

Gender Identity[1]	#	Hispanic	Black	Native American	Asian	White	Veteran	First-Generation
Female	7	2	2	-	-	2	-	2
Male	28	12	3	2	2	17	1	13

[1] Gender Identity: of the 35 interns, only "Female" or "Male" were selected.

Outcomes: Students

To analyze the pilot's quality and impact, we conducted a post-internship survey exploring students':

- interest in transferring to a four-year university,
- change in interest in transferring, based on the internship experience,
- intent to transfer into engineering *specifically*,
- perceptions of how the discipline of the research affected their future study interests, and
- experiences with faculty and graduate student mentors.

Open-ended responses shed light on the impact of the experience on student's perceptions both of their academic/personal growth and understanding of engineering careers.

Participants reported increased interest in and understanding of research practices and future careers. One "Learned so much more about the field I am going into and the different types of work I can expect in my future." Another described growth in research interest, career potential, and opportunities for future study:

> "Ultimately, it [the internship] opened my interests and eyes to a different type of engineering that I did not expect. Also, with seeing how helpful this opportunity was I have become more excited to transfer and get more involved with this project or other projects."

Emerging self-efficacy [19]-[23] as an engineer is evident in the student feedback: "I learned valuable lessons about sticking with topics even if you seem out of place and confused," and I learned an incredibly important skill: to learn by yourself and be self-driven." Participants also learned corollary professional skills: "How to analyze data and then present my findings in a research presentation," and they learned to connect the links between one's present work and that of others who will follow: "I was excited to be able to apply my programming skills to a real-world application and build a lasting legacy to help researchers in the future."

Outcomes: Faculty, Industry, and Graduate-Student Mentors

Our team learned that we need to shape perceptions, manage beliefs, and nurture flexibility among faculty and industry partners. Examples of managing expectations include recognition that community college students are the academic equivalent of first-year or sophomore students; thus, their coursework experience is in the early stages, not nearing degree completion. One faculty member was willing to take a community college student but required that the student had finished a senior-level course to be eligible for the experience. Another faculty member was interested in offering an internship yet needed the student to be available for travel abroad for most of the summer (a fantastic opportunity, but perhaps an unrealistic expectation for a non-traditional student). Industry partners sought students with 3.0 or 3.5 GPAs and/or prior experiences available to students at a university, but not community college students. A university faculty member was interested in a community college student for their research yet listed an application requirement as "high-level experience using Python." Community college students might have introductory experience with one or more computer languages, but high-level experience might be unusual–and even so for many early-stage university undergraduates.

In their concluding feedback, we found that perceptions among faculty and partners had clearly shifted! One faculty member who worked with university students noted that he is always surprised at the lack of knowledge/skill that undergraduates have when they arrive in the lab. In contrast, mentors expressed enthusiasm, and possibly some surprise, that the community college student placed in the lab had demonstrated such high-level talents and insights. We posit that including professional development for faculty and industry mentors on what to expect could be a beneficial addition to future summers [27].

One graduate-student mentor offered feedback for the program—a purchase to support students and train them on professional practices: "We ended up buying the interns cheap (spiral) notebooks so they would remember to write down the things we talked about and not just try to remember everything (and then come ask again in a few hours about the things they forgot). The notebooks really helped and will be part of our intern "welcome package" moving forward. If you have budget, I would highly recommend getting all of the interns notebooks along with a quick speech about writing things down (both that you're asked to do and that you are working on). SPUR is amazing! Thanks for your help getting great students in our lab!"

The community college students showed that they could step into rigorous settings and succeed. One faculty member embedded the community college student into the laddered structure of the lab: "It worked well; in my case I had my university undergraduate student help mentor the community college student." Of a community college student, one faculty mentor stated, "By the end of the summer, he was one of my best students. I think this was a great experience for him." Further, the internship deepened the transfer intentions of that student, who "will transfer to

Boulder next year, and be in at least one of my classes." A graduate-student mentor commented, "Our community college student was able to integrate into our research well and was essentially the same as a university undergraduate student, save for a few courses that they had not completed yet and so did not have all the relevant knowledge." Another stated, "We loved having [student] in our group. He had just finished his freshman year, so he was noticeably less experienced than the others (Senior and Junior). Regardless, he made great contributions and was a wonderful asset to the team." Yet another observed, "The student was excellent and disciplined."

Even when the research deliverables were not as significant as mentors hoped, the program fulfilled promise as a development of young talent. A graduate-student mentor observed, "This was a great experience for [student]. While I would have liked to have more research output, [student] got to meet a lot of university students and create a community for him once he transfers into Boulder. I think the program is doing what it is meant to do so I would be happy to host another Community College student next year." A graduate student mentor offered this suggestion for the future: "Maybe have one social gathering between mentors and students to encourage more community building early on."

A faculty mentor who **did not** host a community college student noted an identical need: "The main thing that was lacking in our lab this summer was casual socialization…so I think more program encouragement/enabling of that would be nice. I think it can be hard to remember that lab bonding and the casual advice that comes from just chatting over lunch is a valuable takeaway from summer internships/programs [28]-[43]."

Contributions to Engineering Education

We seek to broaden participation in engineering studies by underrepresented students, many of whom begin STEM studies in community colleges. Our hypothesis is that by developing:

- clear, accessible, and supported pathways to two-year associate degrees,
- internships with engineering employers, and
- transfer opportunities to four-year research institutions and subsequent bachelor's degree attainment

we can positively change the longstanding inequities in degree completion and entry into high-wage engineering careers.

We are confident that this program *will continue to* provide quality research experiences for community college students as they learn about and pursue engineering careers. As we proceed through our five-stage program implementation (Figure 1), we believe that Engineering Momentum has the potential to close equity and access gaps for minoritized students in our region. Furthermore, based on our model, experience, and outcomes, we offer our program to be adopted or adapted in other states to transform their own contexts.

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References

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

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

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

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

[5] "Dismantling Deficit Thinking: A strengths-based inquiry into the experiences of transfer students in and out of academic libraries – In the Library with the Lead Pipe." [Online]. Available: https://www.inthelibrarywiththeleadpipe.org/2019/dismantling-deficit-thinking/

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

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

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

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

[10] C. Heinbach, B.P. Fiedler, R. Mitola, and E. Pattni, "Dismantling deficit thinking: A strengths-based inquiry into the experiences of transfer students in and out of academic libraries," *The Library with the Lead Pipe,* pp. 498-510, 2019. [Online]. Available: https://www.inthelibrarywiththeleadpipe.org/2019/dismantling-deficit-thinking/

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

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

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

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

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

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

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

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

[19] J. F. R. A. and P. L. C. R. Center, "What We Know About Transfer Outcomes and How Colleges Can Improve Them," Accessed: Feb. 07, 2024. [Online]. Available: https://ccrc.tc.columbia.edu/presentation/what-we-know-transfer-outcomes-how-colleges-can-improve-them-nebhe.html

[20] A. Bandura, "Self-efficacy mechanism in human agency," *American Psychologist,* vol. 37, no. 2, pp. 122–147, 1982. [Online]. Available: https://doi.org/10.1037/0003-066X.37.2.122

[21] A. Bandura, "Self-efficacy: Toward a unifying theory of behavior change," *Psychological Review,* vol. 84, pp. 191-215, 1977.

[22] A. Bandura, *Self-efficacy: The exercise of control,* New York, 1997.

[23] A. Bandura and D.H. Schunk, "Cultivating competence, self-efficacy, and intrinsic interest through proximal self-motivation," *Journal of Personality and Social Psychology,* vol. 41, pp. 586-598, 1981.

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

[25] S. J. Handel, “Second chance, not second class: A blueprint for community-college transfer,” *Change: The Magazine of Higher Learning,* vol. 39, no. 5, pp. 38-45, 2007. [Online]. Available: https://doi.org/10.3200/CHNG.39.5.38-45

[26] C. Maliszewski Lukszo and S. Hayes, “Facilitating transfer student success: Exploring sources of transfer student capital,” *Community College Review,* vol. 48, no. 1, pp. 31-54, 2020. [Online]. Available: https://doi.org/10.1177/0091552119876017

[27] B. Wai-Ling Packard, Successful STEM Mentoring Initiatives for Underrepresented Students: A Research-Based Guide for Faculty and Administrators, 2nd ed., New York, NY, USA: Routledge, 2023.

[28] S. R. Barley and J. E. Orr, *Between Craft and Science: Technical Work in the United States,* Cornell University Press, 2018.

[29] G. D. Young, D. B. Knight, L. M. Warburton, and C. D. Ciechon, “Developing student-centered partnerships: Professional socialization and the transition to industry,” presented at the 2016 ASEE Annual Conference & Exposition, Jun. 2016. [Online]. Available: https://peer.asee.org/developing-student-centered-partnerships-professional-socialization-and-the-transition-to-industry

[30] B. Goldschneider, N. P. Pitterson, and J. M. Case, “Disciplinary socialization in first-year STEM students,” presented at the 2020 ASEE Virtual Annual Conference Content Access, Jun. 2020. [Online]. Available: https://peer.asee.org/disciplinary-socialization-in-first-year-stem-students

[31] National Academy of Engineering, *Educating the Engineer of 2020: Adapting Engineering Education to the New Century,* National Academies Press, 2005.

[32] T. Litzinger, L. R. Lattuca, R. Hadgraft, and W. Newstetter, “Engineering education and the development of expertise,” *Journal of Engineering Education,* vol. 100, no. 1, pp. 123–150, 2011. [Online]. Available: https://doi.org/10.100 2/j.2168-9830.2011.tb00006.x.

[33] J. Harwood, “Engineering education between science and practice: Rethinking the historiography,” *History and Technology,* vol. 22, no. 1, pp. 53–79, Mar. 2006. [Online]. Available: https://doi.org/10.1080/07341510500497210.

[34] A. Reich, D. Rooney, A. Gardner, K. Willey, D. Boud, and T. Fitzgerald, “Engineers’ professional learning: a practice-theory perspective,” *European Journal of Engineering Education,* vol. 40, no. 4, pp. 366–379, Jul. 2015. [Online]. Available: https://doi.org/10.1080/03043797.2014.967181.

[35] B.E. Hughes and S. Hurtado, “Investing in the future: Testing the efficacy of socialization within undergraduate engineering degree programs,” presented at Association of the Study of Higher Education Annual Conference, St. Louis, MO, November 2013. [Online]. Available: http://heri. ucla. edu/nih/downloads/ASHE2013-Investing-in-the-Future.

[36] H. Kamanda, “The role of expectations in the educational experience and professional socialization of engineering students*,” Journal of Higher Education Theory and Practice,* 2015.

[37] D. S. Anderson and J. S. Western, “Notes on a study of professional socialization,” *The Australian and New Zealand Journal of Sociology,* vol. 3, no. 1, pp. 67–71, Mar. 1967. [Online]. Available: https://doi.org/10.1177/144078336700300106.

[38] C. Seron, S. S. Silbey, E. Cech, and B. Rubineau, “Persistence is cultural: Professional socialization and the reproduction of sex segregation,” *Work and Occupations,* vol. 43, no. 2, pp. 178–214, May 2016. [Online]. Available: https://doi.org/10.1177/0730888415618728.

[39] E. Goold, “Professional formation of engineers: Enhancing the first year student experience,” *Conference Papers,* Jan. 2015. [Online]. Available: https://doi.org/10.21427/qavh-j718.

[40] K. Keltikangas and M. Martinsuo, “Professional socialization of electrical engineers in university education,” *European Journal of Engineering Education,* vol. 34, no. 1, pp. 87–95, Mar. 2009. [Online]. Available: https://doi.org/10.1080/03043790902721470.

[41] C. D. Wylie and S. J. Kim, “Socialization, tacit knowledge, and conceptions of ‘experience’ among engineers,” *Engineering Studies,* vol. 14, no. 1, pp. 17–33, Jan. 2022. [Online]. Available: https://doi.org/10.1080/19378629.2022.2037617.

[42] J. Trevelyan, “Mind the gaps: Engineering education and practice,” in *Proceedings of the 21st annual conference for the Australasian Association for Engineering Education,* 2010.

[43] T. S. Henderson, C. J. Finelli, and J. M. Millunchick, “Work in Progress: Undergraduate socialization in engineering: The role of institutional tactics and proactive behaviors,” presented at the 2018 ASEE Annual Conference & Exposition, Jun. 2018. [Online]. Available: https://peer.asee.org/work-in-progress-undergraduate-socialization-in-engineering-the-role-of-institutional-tactics-and-proactive-behaviors.