

Strengthening Engineering Education for Tomorrow's Workforce: Scaling a National Model through Curriculum, Credit, and Community (NSF EEC)

Dr. Stacy S Klein-Gardner, Engineering for US All

Dr. Klein-Gardner focuses on engineering education, particularly at the K-12 level. She is the founding Executive Director of Engineering for US All (e4usa), the non-profit company, and previously served as the co-PI and co-Director of the university-based NSF-funded Engineering for US All (e4usa) project. A member of the Vanderbilt University faculty since 1999 and as a former associate dean, Dr. Klein-Gardner currently serves as an Adjunct Professor of Biomedical Engineering, where she also provides educational evaluation of the two-course sequence in the Vanderbilt Institute for Surgery and Engineering's NIH-funded T32 Training Grant. Dr. Klein-Gardner taught high school precalculus, AP Physics, and Biomedical Engineering-based physics for over 20 years, full- or part-time, and continues to enjoy that interaction by volunteering in a local e4usa class. She is very active in the American Society for Engineering Education (ASEE), having formerly served as chair of the ASEE P12 Commission and the Precollege (PCEE) division. She is a Fellow of ASEE and AIMBE.

Dr. Jennifer Kouo, The Johns Hopkins University

Dr. Jennifer Kouo is an Assistant Research Scientist at the Center for Technology in Education (CTE) within the Johns Hopkins University School of Education. Her research expertise encompasses Universal Design for Learning, technology integration, assistive technologies, and special education for individuals with disabilities, with a particular focus on autism spectrum disorder. Dr. Kouo currently leads and contributes to transdisciplinary research initiatives spanning engineering, medicine, and technology, with additional work in teacher preparation and evidence-based practices across multiple contexts. Her scholarship has been published in the Journal of Autism and Developmental Disorders, Review Journal of Autism and Developmental Disorders, Focus on Autism and Other Developmental Disabilities, and the Journal of Science Education for Students with Disabilities.

Prior to her current role, Dr. Kouo served as an Assistant Professor in the Department of Special Education at Towson University and as a special education teacher at the Kennedy Krieger School: Fairmount Campus. She holds a B.S. in Integrated Elementary and Special Education from Towson University, an M.S. in Special Education from Johns Hopkins University, and a Ph.D. in Special Education with an emphasis in severe disabilities and autism spectrum disorder from the University of Maryland, College Park.

Katie McKeown

Dr. Katie McKeown works for Engineering for US All (e4usa™), 501(c)(3), as the Business Operations Coordinator and Director of Assessments after four years of supporting e4usa alongside her graduate school work. She is passionate about low-income and first-generation college student and STEM education experiences. She currently works in these areas as co-founder/board member of Duke First, founder/director of Packs of Hope, 501(c)(3), and a mentor in different education spaces. Dr. McKeown graduated with a Ph.D. and Masters in Mathematics from the University of Alabama and her A.B. in Mathematics from Duke University.

Dr. Andrew Green, Engineering For US All (e4usa)

Andrew Green is the Director of Partnerships and Communications at e4usa, where he leads national partnership development and strategic communications to expand engineering education and strengthen workforce pathways. He holds a Ph.D. in Higher Education and an MBA from Florida International University. His doctoral research used critical discourse historical analysis to examine how audit-driven, metrics-focused definitions of "student success" shape higher education practices, particularly in engineering, and how professionals navigate the tension between institutional accountability and the nuanced realities of student experiences. At e4usa, Andrew brings this perspective to his work by prioritizing partnership models and program strategies that value real-world learning, flexibility, and diverse pathways into engineering.

Prior to e4usa, he served in FIU's College of Engineering and Computing, where he led K–12 initiatives such as Engineers on Wheels, helping build stronger connections between schools, universities, and the future engineering workforce.

Abubakr Hamid, Engineering for US All (e4usa)

Abubakr Hamid is the Chief Program Officer at Engineering for US All (e4usa), where he supports the development and implementation of research-based engineering curricula. He holds degrees in Electrical and Computer Engineering, Systems Engineering, and Aerospace Engineering, and is a certified Project Management Professional (PMP). His professional experience spans engineering, systems design, and program management. His current work focuses on driving program excellence, strengthening organizational capacity, and advancing pathways into engineering education and the future workforce.

NSF EEC Strengthening Engineering Education for Tomorrow's Workforce: Scaling a National Model through Curriculum, Credit, and Community

Abstract

As the demands of the 21st century workforce continue to evolve, the need for high-quality engineering education at the secondary level has never been more pressing. However, many schools across the country face persistent barriers, including restrictive prerequisites that narrow, instead of broaden, participation or insufficient professional learning opportunities for educators.

With the support of the NSF Engineering Education Division-supported grant titled “Strengthening Engineering Education for Tomorrow’s Workforce,” Engineering for US All (e4usa™) is expanding to address the issues facing secondary engineering education. The goals of the project include expanding implementation to 200 schools across 30 states, increasing the number of universities awarding academic credit for e4usa courses, and strengthening the program’s organizational infrastructure. Central to this effort is MyDesign®, a digital platform designed to deliver professional development and foster a national community of practice among teachers. Complementing this is the refinement of the e4usa end-of-course assessment through the MyDesign® platform, which provides students access to digital design portfolios while offering educators structured rubrics and grading support.

As of Fall 2025, 29 institutions across 15 US states have established pathways for students to earn college credit and placement upon successful completion of e4usa courses in high school. Approaches include traditional dual enrollment agreements, credit awarded through proficiency examinations, and faculty review of student design portfolios. In the case of e4usa, alignment with the College Board’s® Advanced Placement framework enables students to sit for the AP® Computer Science Principles exam. In addition, universities have embedded e4usa into their first-year engineering experience or integrated e4usa coursework into existing undergraduate courses. These pathways validate the rigor of the curriculum, strengthen student motivation, and connect high school learning to postsecondary opportunities.

The paper presents the discernible impact of e4usa across the country. Findings indicated that students feel more confident in their ability to solve real world problems, and educators, many of whom are not trained engineers, share that they feel supported and energized by the training and resources e4usa provides. Partnerships with universities and industry liaisons further enhance program implementation by connecting classroom experiences with authentic applications and offer opportunities for credit for prior learning. The e4usa model not only advances students’ problem-solving and design skills but also cultivates sustainable collaborations that benefit schools and communities. Furthermore, the paper discusses lessons learned in scaling a national initiative from NSF funding to independent non-profit status, with particular attention to sustaining program quality while centering on the experiences of teachers and students.

Keywords: engineering education, teacher professional development, assessment, credit and placement

NSF EEC Strengthening Engineering Education for Tomorrow's Workforce: Scaling a National Model through Curriculum, Credit, and Community

Introduction

As the demands of the twenty-first-century workforce continue to evolve, the preparation of future engineers has become a national priority. Engineers are increasingly expected to address complex, real-world problems that require not only technical competence, but also systems thinking, collaboration, ethical reasoning, and the ability to work across disciplines and communities [1]. National reports consistently emphasize that developing these competencies requires earlier and broader exposure to engineering practices, positioning secondary education as a critical entry point for strengthening the future engineering workforce and supporting economic competitiveness [2] - [3].

High-quality, accessible engineering education at the secondary level plays an essential role in preparing students for postsecondary study and the workforce while also promoting engineering literacy for all learners. Research indicates that early engagement with engineering can increase student interest in STEM careers, improve problem-solving skills, and support persistence in postsecondary STEM pathways. Despite this growing recognition, access to rigorous secondary engineering coursework remains inconsistent across the United States. Participation in engineering courses continues to reflect disparities across race, gender, socioeconomic status, and geography, limiting the diversity and size of the future engineering workforce [4].

Project Overview and Goals

For more than 23 years, Engineering for US All (e4usa™) has worked to transform high school engineering education and prepare students to become tomorrow's engineers. The organization advances this mission through interconnected efforts that include continuous curriculum development, teacher professional learning, and scaling the e4usa Hub. e4usa is also strengthening its technology ecosystem—most notably the MyDesign® LMS and end-of-course assessments—while growing a national network of state, school, industry, and university partners that support student credit and placement. Strategic collaborations, including with the College Board®, further extend the program's reach and sustainability.

e4usa introduces all students to engineering while supporting educators in preparing a skilled future workforce. To date, the program has served more than 10,000 students in 105 high schools, partnered with 39 universities, and continues to expand through state-level collaborations. Teachers are recruited through multiple, complementary pathways. Recruitment strategies include outreach at national and regional conferences, partnerships with school districts and state agencies, targeted e-mail campaigns, informational webinars, social media, and referrals through professional networks and word of mouth from participating educators. In some contexts, recruitment begins at the district or state level, while in others it is driven by individual teachers seeking to expand engineering offerings at their schools. When available, external funding has supported scholarships to offset initial participation costs. During the earlier phases of the program, teacher stipends were offered through NSF and state-level funding; however, as the initiative transitioned to an independent 501(c)(3) nonprofit, the model shifted away from direct financial incentives toward sustainability through program value and institutional partnerships. Teachers retention is primarily supported through the quality and continuity of the professional development experiences rather than ongoing monetary incentives. By deepening student learning in engineering design and investing in sustained professional development, e4usa is building a scalable nonprofit model with national impact.

As presented in Figure 1, “Strengthening Engineering Education for Tomorrow's Workforce,” funded by the NSF Division of Engineering Education and Centers (EEC), supports e4usa in addressing persistent

challenges in secondary engineering education. Project goals include expanding to 200 schools in 30 states, increasing university credit pathways, and strengthening organizational infrastructure. Central to this work is the e4usa Hub, which delivers professional learning and fosters a national community of practice, alongside continued refinement of the MyDesign end-of-course assessment and digital design portfolio system.

Figure 1

Theory of Action Guiding “Strengthening Engineering Education for Tomorrow’s Workforce”



e4usa Courses

e4usa+Making

A yearlong, project-based engineering course focused on core design practices and hands-on prototyping. Students use a systematic design process to build skills in sketching, CAD, and fabrication, with an emphasis on human-centered design and iteration. Work is captured in design portfolios assessed with the MyDesign rubric, and many schools pair the course with an industry CAD credential. The course builds technical fluency alongside

teamwork and communication skills for early engineering pathways.

e4usa+Programming

A yearlong course that integrates computational thinking and programming into engineering design. Students use MATLAB for data analysis, algorithms, and systems modeling, aligning with the AP® Computer Science Principles framework from College Board. Design portfolios are assessed with the MyDesign rubric, and students may earn a MATLAB credential from MathWorks® or pursue AP® CSP credit, depending on local policy.

e4usa+Design

An advanced, yearlong engineering design course for students with prior experience in e4usa+Making. Students tackle complex, open-ended problems with authentic clients emphasizing systems thinking, iteration, and manufacturability, moving from global challenges to local or personal ones. The course culminates in comprehensive portfolios and public showcases, assessed with the MyDesign rubric.

e4usa Legacy

A yearlong introductory engineering course that serves as an onramp for high school students. Through scaffolded, team-based challenges, students explore engineering's role in society and learn the

engineering design process while working with authentic clients. Students document their work in portfolios assessed with the MyDesign rubric, making the course well-suited for schools offering a single, comprehensive engineering option.

Educators and Digital Infrastructure for Scaling

Teacher Professional Learning

e4usa offers year-round professional learning to support both new and returning teachers in effective curriculum implementation and continued pedagogical growth. Professional development is co-designed with educators, responsive to their needs, and delivered through the e4usa Hub to sustain a national community of practice. Yearlong learning begins with Summer Professional Development (PD), followed by ongoing supports that are targeted, comprehensive, and flexible to help deepen and refine their pedagogical practice.

New e4usa Teachers

New e4usa teachers begin with an introductory Summer PD that provides a foundational overview of e4usa and prepares them for course-specific training. They then complete course-specific New Teacher Summer PD, which emphasizes hands-on engagement with early curriculum units, inclusive instructional strategies, planning for community-based projects, and an introduction to the MyDesign® Scoring Rubric.

In the fall, teachers participate in an asynchronous MyDesign® 1: Get to Know MyDesign® PD to deepen their understanding of the rubric and its integration across e4usa lessons. Midyear learning continues with Winter PD, which supports preparation for Units 3 and 4 engineering design projects and addresses educator-identified needs such as CAD, MyDesign, project management, and student writing. Throughout the year, new teachers engage in Teacher Progress Snapshots and Reflections (TPSR) to reflect on practice, track goals, share insights with the e4usa community, and inform continuous improvement of the curriculum and professional learning system.

Returning e4usa Teachers

Returning e4usa teachers engage in targeted, shorter professional development opportunities aligned to their professional goals. These flexible offerings, which are responsive to educator needs, include topics such as MATLAB®, MyDesign®, and CAD, supporting continued growth and refinement of pedagogical practice.

e4usa Hub and Community of Practice

Launched in June 2024 and co-designed with educators, the e4usa Hub centralizes previously fragmented tools into a single platform that anchors the e4usa Community of Practice. Through the Hub, teachers access professional learning and communicate with experienced e4usa Coaches and e4usa Fellows, who are experienced returning e4usa educators. e4usa Connect enables nationwide peer collaboration through discussion threads for sharing questions, materials, student work, and successes. Community building is further supported with social and celebratory events, and by university and industry liaisons who provide teachers and their students with additional engineering expertise and resources.

MyDesign® Scoring Rubric and Learning Management System

The MyDesign scoring rubric provides a valid, reliable approach for assessing engineering design portfolios in e4usa [5]. The MyDesign LMS embeds the rubric in a web-based platform that supports organization and scoring at scale. e4usa offers ongoing PD to support effective use of both the rubric and LMS. Trained e4usa graders evaluate portfolios submitted through MyDesign, with inter-rater reliability analyses informing continuous improvements to grader training and teacher PD.

Postsecondary Credit and Placement Pathways

As of Fall 2025, 29 postsecondary institutions across 15 U.S. states offer formal pathways for academic credit or placement based on successful completion of an e4usa high school course. Participating institutions reflect broad recognition of the curriculum’s rigor, relevance, and adaptability across engineering and technology degree programs. Partner institutions use multiple mechanisms to validate learning and award credit, as summarized in Table 1.

Table 1

University Credit and Placement Pathways

Credit and Placement Mechanisms	Description
Dual Enrollment	Some institutions offer concurrent or dual enrollment, allowing students to earn transcribed college credit while in high school through alignment with introductory engineering courses (e.g., Arizona State University; The College of New Jersey; Lincoln Memorial University).
Proficiency Exams	Several universities award credit through portfolio review paired with a written or departmental exam (e.g., University of Maryland; Regent University; Virginia Tech).
Faculty Evaluation of Design Portfolios	Many institutions grant credit based on faculty evaluation of student design portfolios demonstrating course outcomes, (e.g., Purdue University, Towson University, East Carolina University, and West Virginia University).

Alignment with AP® frameworks

The e4usa+Programming course aligns with the AP® Computer Science Principles framework, enabling students to sit for the AP CSP exam and earn credit recognized by many institutions. This alignment strengthens links between high school engineering, computing pathways, and college credit. Several universities also integrate e4usa-aligned coursework directly into first-year engineering pathways. For example, the University of Oklahoma has adapted e4usa design practices into a redesigned first-year sequence.

Established credit pathways validate the rigor of the e4usa curriculum, motivate students by assigning tangible postsecondary value to design work, and strengthen high school–university partnerships that support long-term workforce development.

Implementation and Impact Findings

As presented in Table 2, e4usa is grounded in research and supported by an extensive body of publications demonstrating the effectiveness of its curriculum and teaching practices. The Hub engages 124 e4usa educators, team members, and supporters. This robust evidence base and metrics reinforces e4usa’s credibility, informs ongoing curriculum and professional learning improvements, and guides its expansion nationwide.

Scaling a National Program: Lessons Learned

A key goal of e4usa’s NSF funding was sustainability and growth. To achieve this, a 501(c)(3) non-profit was launched. To ensure continuity and fidelity at scale, members from the grant transitioned to various roles in the non-profit.

e4usa continually evolves its curriculum and PD based on research and feedback. New offerings include advanced PD for returning teachers and a yearlong e4usa+Programming course, supported by

MathWorks. The e4usa Hub has been expanded, and partnerships with universities and industry bring engineers into classrooms while growing credit and placement pathways. Challenges include establishing core business practices previously handled by universities, implementing systems like customer service management, and securing diverse funding streams amid shifting federal policies.

Table 2

Summary of Research Supporting e4usa

Category	Citations	Brief Summary of Results
Curriculum	[6-11]	The e4usa curriculum integrates discovery, design, professional skills, societal context, and programming, with instructional “threads” ensuring coherent, high-fidelity implementation. Research also examines COVID-era remote learning, active learning, and programming integration, highlighting challenges and adaptations that inform effective, inclusive pre-college engineering education.
Professional Learning	[12-16]	Studies show that hands-on learning, reflective practice, and communities of practice are key to high-quality, inclusive engineering education.
Community of Practice (counselors, liaisons, administrators)	[17-24]	Research highlights how administrators, counselors, and parents influence adoption of high school engineering curricula and broaden participation, identifying structural enablers and barriers. Targeted counselor PD and increased stakeholder awareness help address bias, improve guidance, and strengthen support for equitable access to pre-college engineering.
Teacher Outcomes	[25-36]	Research shows e4usa PD boosts teacher confidence, reduces imposter syndrome, and fosters inclusive, human-centered teaching practices.
Student Outcomes	[37-51]	Research shows that hands-on, project-based, human-centered learning boosts student engagement, confidence, creativity, and interest in engineering. Students value collaboration, design projects, and flexibility, with evidence of increased engineering self-efficacy and career interest, particularly among female students, even during COVID-19 remote learning.

Conclusion

e4usa has advanced secondary engineering education through a research-backed, scalable model of hands-on, design-focused, inclusive learning. Its integrated curriculum, professional development, and community of practice support diverse students and help educators adopt human-centered, reflective practices. These efforts inform policy on structured curricula, sustained professional learning, and credit pathways, while partnerships with universities and industry strengthen workforce readiness and equitable STEM access. Future research may explore long-term student outcomes, implementation fidelity across contexts, and the use of emerging technologies to enhance design-based learning and teacher development.

Acknowledgments

Engineering for US All (e4usa™) is supported by the National Science Foundation under NSF Awards Numbers 1849430, 2120746, 2323098, 2323684. Any opinions, findings, conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect those of the National Science Foundation.

References

- [1] National Academy of Engineering, *The Engineer of 2020: Visions of Engineering in the New Century*. Washington, DC, USA: National Academies Press, 2004.
- [2] L. Katehi, G. Pearson, and M. Feder, Eds., *Engineering in K–12 Education: Understanding the Status and Improving the Prospects*. Washington, DC, USA: National Academies Press, 2009.
- [3] National Research Council, *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC, USA: National Academies Press, 2012.
- [4] National Academies of Sciences, Engineering, and Medicine, *Equity in K–12 STEM Education: Framing Decisions for the Future*. Washington, DC, USA: National Academies Press, 2023.
- [5] S. Klein-Gardner, L. Abts, and G. Goldberg, “The Engineering Design Process Portfolio Scoring Rubric (EDPPSR): Initial validity and reliability,” in *Proc. ASEE Annu. Conf. Expo.*, Minneapolis, MN, USA, 2022. doi: 10.18260/1-2--41236.
- [6] K. Reid, K. Ladeji-Osias, C. Beauchamp, M. Dalal, T. Griesinger, and E. Eagle, “Design by thread: The Engineering for Us All (e4usa) curriculum,” in *Proc. ASEE/IEEE Frontiers Educ. Conf. (FIE)*, 2020. doi: 10.1109/FIE44824.2020.9274008.
- [7] K. Reid and T. Griesinger, “Effect of COVID on a high school engineering curriculum (work in progress),” in *Proc. ASEE Virtual Annu. Conf. Expo.*, 2021. doi: 10.18260/1-2--37007.
- [8] K. Reid and T. Griesinger, “A high school engineering curriculum focusing on discovery, design, professional skills and society,” in *Proc. World Eng. Educ. Forum/Global Eng. Deans Council (WEEF/GEDC)*, 2021. doi: 10.1109/WEEF/GEDC53299.2021.9657474.
- [9] O. Emiola-Owolabi, K. Ladeji-Osias, and M. Dalal, “High school students’ perspective of active learning in a remote classroom (fundamental),” in *Proc. ASEE Virtual Annu. Conf. Expo.*, 2021. doi: 10.18260/1-2--37244.
- [10] K. Reid, C. Beauchamp, and S. S. Klein-Gardner, “Programming as an engineering tool in K–12: e4usa+Programming—Introducing the purple thread,” in *Proc. ASEE Annu. Conf. Expo.*, Montreal, QC, Canada, 2025. doi: 10.18260/1-2--57077.
- [11] X. Wi, J. Wu, S. Klein-Gardner, and M. Dalal, “Evaluating fidelity of teaching in pre-college engineering: A case study of curriculum implementation,” in *Proc. Amer. Eval. Assoc. Conf.*, Kansas City, MO, USA, 2025.
- [12] J. L. Kouo *et al.*, “Initial investigation of effective teacher professional development among experienced and non-experienced engineering teachers,” in *Proc. ASEE Virtual Annu. Conf. Expo.*, 2020. doi: 10.18260/1-2--35547.
- [13] J. L. Kouo, S. S. Klein-Gardner, M. Dalal, and E. Eagle, “When a pandemic requires a pivot in the modality of teacher professional development (work in progress),” in *Proc. ASEE Virtual Annu. Conf. Expo.*, 2021. doi: 10.18260/1-2--38054.
- [14] A. R. Carberry, S. S. Klein-Gardner, P. S. Lottero-Perdue, and K. L. Shirey, “Pre-college engineering education teacher preparation,” in *International Handbook of Engineering Education Research*, A. Johri, Ed. London, UK: Routledge, 2023, pp. 241–262. doi: 10.4324/9781003287483-15.
- [15] M. Dalal, T. Nkrumah, J. Kouo, and S. Klein-Gardner, “Examining teacher perspectives of gender stereotyping in pre-college engineering education,” in *Mentoring Through a Female STEM Identity Lens*, C. Craig, Ed. Wilmington, DE, USA: Vernon Press, 2024.
- [16] M. Dalal, C. LaChapelle, K. Reid, V. Vinayak, and K. McKeown, “Evolving together: The role of teacher feedback in shaping the curriculum of a pre-college engineering program,” in *Proc. ASEE Annu. Conf. Expo.*, Montreal, QC, Canada, 2025. doi: 10.18260/1-2--57266.

- [17] M. Dalal and A. Carberry, "Enabling factors and barriers for adopting engineering curricula in high schools: School, district, and state administrator perspectives (fundamental)," in *Proc. ASEE Virtual Annu. Conf. Expo.*, 2021. doi: 10.18260/1-2--37029.
- [18] J. Chipps and S. S. Klein-Gardner, "Administrator's perspectives on an engineering program aimed at broadening participation," in *Proc. ASEE Annu. Conf. Expo.*, Baltimore, MD, USA, 2023. doi: 10.18260/1-2--42581.
- [19] J. Chipps, M. Dalal, A. R. Carberry, and J. Kouo, "Exploration of the role and needs of high school counselors in supporting broader participation within engineering fields," in *Proc. CoNECD Conf.*, New Orleans, LA, USA, 2023. doi: 10.18260/1-2--44794.
- [20] X. Wei, J. Wu, and S. S. Klein-Gardner, "Parents' knowledge, attitude and behavior on pre-college engineering education course (work in progress)," in *Proc. American Society for Engineering Education (ASEE) Annu. Conf. Expo.*, Montreal, QC, Canada, 2025. doi: 10.18260/1-2--55568.
- [21] L. Ross, M. Dalal, A. R. Carberry, and J. Roarty, "Professional development program for high school counselors on the engineering design process (evaluation)," in *Proc. ASEE Virtual Annu. Conf. Expo.*, 2021. doi: 10.18260/1-2--37604.
- [22] J. Roarty, M. Dalal, L. Ross, and A. Carberry, "Examining the influence of a professional development program on high school counselors' practices regarding engineering," in *Proc. ASEE/IEEE Frontiers Educ. Conf. (FIE)*, Lincoln, NE, USA, 2021. doi: 10.1109/FIE49875.2021.9637308.
- [23] M. Dalal and L. Ross, "Whistling Vivaldi: Examining stereotypes and implicit biases in the context of engineering career counseling," in *Proc. Amer. Educ. Res. Assoc. (AERA) Annu. Meeting*, San Diego, CA, USA, 2022.
- [24] L. Ross, M. Dalal, and A. R. Carberry, "Expanding access to STEM pathways: Professional learning for high school counselors," *School Sci. Math.*, vol. 123, no. 3, pp. 102–113, 2023. doi: 10.1111/ssm.12576.
- [25] K. Reid, M. Dalal, and C. Beauchamp, "A music teacher teaches engineering and uses CAD: A case study," in *Proc. Society for Information Technology & Teacher Education Int. Conf.*, D. Schmidt-Crawford, Ed., pp. 1311–1316. Online: Association for the Advancement of Computing in Education (AACE), 2020. [Online]. Available: <https://www.learntechlib.org/p/215897/>
- [26] M. Dalal, A. R. Carberry, D. Warmington, and R. Maxwell, "A case study exploring transfer of pedagogical philosophy from music to engineering," in *Proc. ASEE/IEEE Frontiers Educ. Conf. (FIE)*, 2020. doi: 10.1109/FIE44824.2020.9274128.
- [27] B. Berhane, M. Dalal, S. Klein-Gardner, A. Carberry, K. Reid, C. Beauchamp, J. Kouo, and D. Pines, "Understanding the 'us all' in Engineering 4 Us All through the experiences of high school teachers," in *Proc. Collaborative Network for Engineering and Computing Diversity (CoNECD) Conf.*, 2021. doi: 10.18260/1-2--36132.
- [28] A. R. Carberry, M. Dalal, M. Nagda, and B. McCarthy, "Expanding the STEM teacher pool: A history teacher's experience teaching a high school engineering course," in *Proc. National Association of Research in Science Teaching (NARST) Annu. Conf.*, 2021.
- [29] M. Dalal, S. Klein-Gardner, J. Kouo, K. Reid, C. Beauchamp, B. O'Neal, J. Lopez-Roshwalb, and D. Pines, "Stereotypes and implicit biases in engineering: Will students need to 'Whistle Vivaldi'?" in *Proc. Collaborative Network for Engineering and Computing Diversity (CoNECD) Conf.*, 2021. doi: 10.18260/1-2--36122.
- [30] O. Emiola-Owolabi, M. Dalal, and K. Ladeji-Osias, "High school teachers' conceptualizations of engineering teaching," in *Proc. Amer. Educ. Res. Assoc. (AERA) Annu. Meeting*, 2021.

- [31] M. Dalal, A. Carberry, and R. Maxwell, "Broadening the pool of pre-college engineering teachers: The path experienced by a music teacher," *IEEE Trans. Educ.*, vol. 65, no. 3, pp. 344–355, 2022. doi: 10.1109/TE.2022.3141984.
- [32] J. Kouo *et al.*, "Understanding the impact of professional development for a cohort of teachers with varying prior teaching and engineering experience," *J. Pre-College Eng. Educ. Res.*, vol. 13, no. 1, pp. 37–54, 2023. doi: 10.7771/2157-9288.1317.
- [33] T. Griesinger, D. Olawale, N. Saqib, and K. Reid, "Assessing the reactionary response of high school engineering teachers offering a novel pre-college engineering curriculum: Lessons learned from the COVID-19 pandemic," *Educ. Sci.*, vol. 13, no. 5, Art. no. 427, 2023. doi: 10.3390/educsci13050427.
- [34] A. Iqbal, A. Carberry, and M. Dalal, "Formative assessment practices in high school classrooms—Experiences of a high school teacher teaching engineering design curriculum," in *Proc. ASEE/IEEE Frontiers Educ. Conf. (FIE)*, College Station, TX, USA, 2023. doi: 10.1109/FIE58773.2023.10342920.
- [35] B. Memarian, M. Dalal, O. V. Emiola-Owolabi, K. J. Reid, T. M. Griesinger, and A. R. Carberry, "Navigating pre-college engineering teaching during COVID-19: A review and analysis of teacher experiences," *J. Online Learn. Res.*, vol. 11, no. 1, pp. 105–139, 2025. doi: 10.70725/224416gbxobx.
- [36] M. Dalal, D. Maitra, S. Rahman, and S. S. Klein-Gardner, "A cross case-study: How pedagogical content knowledge shapes high school engineering instruction," submitted to *J. Pre-College Eng. Educ. Res.*, Nov. 2025.
- [37] M. Dalal, S. Klein-Gardner, J. Kouo, K. Reid, C. Beauchamp, B. O'Neal, J. Lopez-Roshwalb, and D. Pines, "Stereotypes and implicit biases in engineering: Will students need to 'Whistle Vivaldi'?" in *Proc. Collaborative Network for Engineering and Computing Diversity (CoNECD) Conf.*, 2021. doi: 10.18260/1-2--36122.
- [38] E. Lee, A. Carberry, M. Dalal, and M. Miller, "Validation of the engineering design self-efficacy scale for secondary school students (research to practice)," in *Proc. American Society for Engineering Education (ASEE) Virtual Annu. Conf. Expo.*, 2021. doi: 10.18260/1-2--37164.
- [39] M. Dalal, A. Carberry, and O. V. Emiola-Owolabi, "Understanding anchors associated with secondary school students' engineering design experiences," in *Proc. Clive L. Dym Mudd Design Workshop XII*, Virtual, 2021.
- [40] R. Figard, M. Dalal, J. Roarty, S. Nieto, and A. Carberry, "Understanding high school student experiences in an engineering course designed for all (fundamental, diversity)," in *Proc. ASEE Annu. Conf. Expo.*, Minneapolis, MN, USA, 2022. doi: 10.18260/1-2--40476.
- [41] J. L. Kouo, A. E. Hogan, S. Morton, and J. Gregorio, "Supporting students with an autism spectrum disorder in engineering: K–12 and beyond," *J. Sci. Educ.*, vol. 24, no. 1, pp. 1–21, 2021. doi: 10.14448/jsesd.13.0011.
- [42] J. Kouo, J. Chipps, R. Figard, K. Reid, K. Shirey, and S. S. Klein-Gardner, "Broadening participation and the mission of Engineering for Us All (e4usa) through design projects that engage students with disabilities as stakeholders (work in progress)," in *Proc. ASEE Annu. Conf. Expo.*, Baltimore, MD, USA, 2023. doi: 10.18260/1-2--42496.
- [43] R. Figard, S. A. Schill, M. Dalal, and A. R. Carberry, "Examining the unique experiences of transgender and gender nonconforming students in a pre-college engineering course," in *Proc. ASEE Annu. Conf. Expo.*, Baltimore, MD, USA, 2023. doi: 10.18260/1-2--43524.
- [44] N. Léger, S. S. Klein-Gardner, and B. T. Berhane, "Teacher perspectives of outcomes and challenges resulting from students' interactions with MATLAB in e4usa (fundamental)," in *Proc. ASEE Annu. Conf. Expo.*, Baltimore, MD, USA, 2023. doi: 10.18260/1-2--42547.

- [45] J. Kouo, J. Chipps, R. Figard, K. Reid, K. Shirey, and S. S. Klein-Gardner, "Broadening participation and the mission of Engineering for Us All (e4usa) through design projects that engage students with disabilities as stakeholders (work in progress)," in *Proc. American Society for Engineering Education (ASEE) Annu. Conf. Expo.*, Baltimore, MD, USA, 2023. doi: 10.18260/1-2--42496.
- [46] J. Wu, N. Léger, and S. S. Klein-Gardner, "High school students' perspectives on mathematical modeling in the engineering design process," in *Proc. ASEE Annu. Conf. Expo.*, Portland, OR, USA, 2024. doi: 10.18260/1-2--47528.
- [47] J. Wu and M. Dalal, "High school students' perspectives on pre-college engineering education courses," in *Proc. ASEE Annu. Conf. Expo.*, Portland, OR, USA, 2024. doi: 10.18260/1-2--47527.
- [48] S. A. Schill and S. S. Klein-Gardner, "Evaluating a high school engineering community of practice: The perspective of university liaisons (evaluation)," in *Proc. ASEE Annu. Conf. Expo.*, Baltimore, MD, USA, 2023. doi: 10.18260/1-2--43416.
- [49] E. Lee, A. Jannini, M. Dalal, M. Miller, and A. Carberry, "Exploring sources of engineering-related self-efficacy in the context of a pre-college engineering design curriculum," *Stud. Eng. Educ.*, vol. 6, no. 2, pp. 122–141, 2025. doi: 10.21061/see.229.
- [50] J. Wu, M. Dalal, and A. Carberry, "Advancing equity: Exploring the experiences of transgender and gender non-conforming students in a pre-college engineering course (work in progress)," in *Proc. ASEE Annu. Conf. Expo.*, Montreal, QC, Canada, 2025. doi: 10.18260/1-2--57577.
- [51] S. Kavale and M. Dalal, "High school student experiences in engineering: Perspectives and insights (work in progress)," in *Proc. ASEE/IEEE Frontiers Educ. Conf. (FIE)*, Nashville, TN, USA, 2025.