WIP: Opening Doors for All: Creating an Inclusive and Equitable Engineering Education Model Inspired by the ASEE Mindset Report

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I. Introduction

In recent years, ASEE, in partnership with other national organizations such as the NSF, NAE, NAB, and the broader engineering community, has engaged in a multi-year effort to create a set of high-impact recommendations to transform the landscape of engineering education in the 21st century. The **2018 ASEE and NSF report, *Transforming Undergraduate Education in Engineering*** [1], emphasized that the engineers of tomorrow must possess "deep expertise within a single domain, broad knowledge across domains, and the ability to collaborate with others in a diverse working environment." This vision has been echoed in multiple subsequent studies [2-4] focused on educating the engineering workforce of the future. Most recently, the ***2024 ASEE Inclusive Mindset Report*** [5] reinforced the need for a student-ready, equity-centered educational system capable of producing a diverse, agile, and highly skilled workforce.

Together, these reports issue a clarion call for systemic changes in engineering curricula that simultaneously promote breadth of knowledge with sub-disciplinary expertise in specific areas; a combination of technical and professional skills needed for success; and the ability to work within culturally diverse settings. These changes, collectively termed as the KSA's (Knowledge, Skills, and Abilities) required of graduating engineers, emphasize the following:

- Alternative pathways to higher education that remove barriers to participation by groups that are underrepresented in engineering programs;
- An engineering curriculum that promotes experiential learning with three important goals: using multi-modal pedagogies that address the learning needs of diverse learners that meet them "where they are"; integrating math and science instruction with engineering topics that are focused on building skills to solve real-world engineering problems; encouraging student agency and ownership in their own learning;
- A student-centered learning environment that is accessible and diverse, focused on building relationships between students, instructors and other support personnel; emphasizing a "humanized socio-technical approach" that centers an ethical, social-justice paradigm in engineering education; training, evaluating and rewarding instructors for innovations in teaching and learning that meets the needs of students;
- Broad and strategic collaborations that include industry, community, academia and accreditation partners that are created to cater to the specific needs, context and opportunities of engineering programs.

The reports indicate that two broad factors are driving the need for these changes: (1) disruptive changes in the sociotechnical landscape of engineering that are revolutionizing society and engineering at a breathtaking pace; and, (2) the continuing predominance of traditional and exclusionary models of engineering education that leave students ill-prepared to meet the challenges of a rapidly evolving industry and society. To address these evolving challenges, engineering programs need to be unafraid to design transformative engineering educational models that "challenge oppressive systems" and "dismantle oppressive barriers" for the purpose of educating new generations of engineering students that use their knowledge and life experiences towards "socially just action. These recommendations will remove barriers to increase access and diversity and improve instruction leading to better student outcomes that will lead to the next level of excellence in undergraduate engineering education." [5]

In this paper, we describe an ongoing project at the University of Detroit Mercy that proposes a unique model for the freshman year of our engineering programs that is grounded in the recommendations of the ASEE and NSF reports. The model advances equity and inclusivity by challenging exclusionary practices built into existing programs and radically reshaping or discarding those that have been shown to "intentionally or unintentionally harm historically excluded groups in engineering education" [5]. In the next two sections, we expand on the factors driving the need for systemic change in engineering education. In Section IV, we detail our freshman pilot program and its alignment with ASEE and NSF report recommendations.

II: **Sociotechnical Imperatives for Curricular Change**

The current sociotechnical landscapes of society in general, and the engineering profession in particular, are undergoing rapid changes with an unprecedented level of disruption and innovation across technological and social boundaries. These changes are driven by a number of factors, including (a) the transformative impact of Industry 4.0 [6-13] with its emphasis on AI-driven decision making, automation and data analytics; (b) societal disruptions like COVID-19 and other pandemics, and their impact on supply chains, workforce stability and other issues; (c) generational workplace value differences and priorities; and (d) an evolving global economic environment reshaping business models. A recent study of 500 executives across 400 U.S. companies accentuated the findings of the ASEE and NSF reports by outlining three persistent challenges facing the engineering workforce [14]:

- Systemic racism and structural inequities in education have historically excluded African Americans, women, and other minoritized groups from engineering, limiting the diversity of the workforce.
- The demand for STEM jobs continues to outpace the supply of qualified workers.
- STEM careers are evolving rapidly, necessitating adaptable skills and a commitment to lifelong learning.

Rapid technological advancements have placed significant burdens on sectors like law, policy, manufacturing, and human resources [15]. While some sectors adapt quickly, engineering education, constrained by traditional practices, has struggled to address 21st-century challenges and tap into diverse talent pools [3-4, 6, 12-13, 16-17]. There is an urgent need for engineering education to shift from standardized, efficiency-driven models to flexible, inclusive, and personalized approaches that address systemic inequities and align with industry demands [12-13, 18]. However, as discussed, most university engineering programs face structural barriers to implementing these changes.

III: The Exclusionary Nature of Engineering Programs

Higher education, including technical education, was designed for full-time students following a four-year degree path, with processes, financial aid, and tuition models tailored to this "model student." Today, many students are first-generation learners with family responsibilities, working part- or full-time, and coming from under-resourced schools. Many must interrupt their education, starting and stopping due to financial or systemic barriers. Despite the belief that hard work ensures success, socioeconomic status is a stronger predictor of degree completion than academic talent [19]. Engineering education, built for operational efficiency rather than student needs, continues to rely on outdated models [10, 12-13, 18].

Reform efforts have traditionally focused on “fixing” struggling students through pre-college programs, remedial prerequisites, bridge programs and other interventions aimed at making them “college ready” and able to navigate impenetrable mazes of transactional educational pathways. As research has shown, what is needed is for the educational system to be reformed to become “student ready” which, in turn, will require systemic changes to institutions [20] and a mindset that moves away from a deficit thinking approach and addresses student disparities as “equity gaps” rather than “achievement gaps” [20-21].

Data [22] on the demographics of engineering graduates reveal the impact of racism, sexism and other exclusionary structures in limiting access to STEM fields rather than removing barriers and accommodating diverse learners [23]. The current higher education system is exclusionary, requiring college readiness based on narrowly defined skills [24-34] that many underserved schools cannot provide their students. *The Inequality Machine* [35] details how higher education policies exacerbate inequalities through exclusionary admissions, inequitable financial aid, early STEM course filtering, and punitive assessments [25-30], disproportionately affecting minorities, women, and first-generation students [31-34]. University admissions for engineering programs prioritize metrics like GPA, standardized test scores, and advanced placement courses, disproportionately disadvantaging students from under-resourced schools, low-income backgrounds, and those without access to test preparation resources. Meanwhile, qualities like creativity, teamwork, problem-solving, inquisitiveness, lifelong learning, and the motivation to make a positive societal impact that centers ethical and just solutions to real-world engineering problems- critical qualities needed for the engineering workforce of the future—are overlooked.

Even those students who are encouraged to pursue engineering degrees because they are “good at math and science,” encounter engineering disciplines that are divided into disciplinary silos like Mechanical and Electrical Engineering, Physics, Mathematics and so on. By fortifying these divisions, the traditional model is perpetuating an artificial segregation between fields of allied knowledge and expertise needed by engineers. These persistent, outdated disciplinary structures are disconnected from today’s interdisciplinary, innovation-driven technological landscape. Breaking down these barriers is essential to tackle real-world practices and challenges. Furthermore, despite the rapid evolution of STEM careers, students are expected to gain “fundamental” knowledge expertise in isolated subjects based on long-standing but obsolete learning outcomes. In an era where the future of STEM jobs is uncertain and rapidly changing, engineering programs must train students to focus on learning how to learn, solving complex socio-technical problems, and embracing lifelong learning—rather than relying on a fixed set of skills acquired in segregated, uniform classrooms [12].

IV: Freshman Pilot Program Design

A: Introduction

The University of Detroit Mercy is uniquely positioned to address the challenges outlined in the ASEE & NSF reports due to its leadership in the development of the workforce in the

region. Our mission to foster the intellectual, spiritual, ethical, and social development of our students received a tremendous boost through a $21.2 million award from the National Institutes of Health (NIH) BUILD Program [36]. The goal of the program was to increase the representation of minoritized students pursuing biomedical science careers. Over ten years, the College built research partnerships with community colleges and local universities to offer student research opportunities; developed mentoring and advocacy programs for equitable support; collaborated with industry and government leaders, especially from underrepresented groups, as speakers and role models; and launched a faculty training initiative to enhance learning and retention.
Leveraging the success of the NIH grant, the College attracted significant funding from the NSF and other sources to continue to build upon ongoing transformative and equity-based initiatives, including (1) a corporate-funded dual-enrollment program for underserved high school students "who dream of being engineers"; (2) a program to provide engineering students with entrepreneurial opportunities with local industry, supported by the Kern Family Foundation; (3) graduate level certificate and degree programs in product development, electric vehicle technologies, cyber engineering, autonomous vehicles and others in partnership with industry and government [37].

University of Detroit Mercy's diverse student body includes 59% female students and 19% from underrepresented minority groups. Our engineering programs reflect these statistics. Approximately one-third of our student body are first-generation college students whom the traditional structures of higher education have not served well. An overwhelming majority of our engineering graduates have pursued careers in the Metropolitan Detroit area which is home to large communities of Arab, African, and Hispanic ancestry who work in the Automotive industry. These facts provide a compelling reason for our approach to transforming our engineering programs centered on inclusive and equity-based pedagogy.

In the sections below, we introduce our equity-centered redesigned freshman engineering program. Given the complex nature of the redesign project, our implementation is focused on the freshman year of the mechanical and electrical engineering programs, starting with a small cohort of students. The project goals include disrupting legacy barriers such as restrictive prerequisites, inflexible semester-based course schedules, and traditional assessment methods that have disproportionately affected marginalized students. This pilot program does not replace the traditional pathway most engineering students follow. Instead, students in the redesigned freshman curriculum will transition into the traditional pathway after their first year in the program. Our hope is to expand the redesign into years 2-4 in future years based on the lessons learned through the pilot.

B: Pedagogical Design Innovations

The centerpiece of our pilot program lies in our curricular redesign plan which combines all first-year physics, math and engineering lectures and laboratory instruction in a single, year-long studio-style course that accounts for twenty-one of the thirty-two credit hours completed by first-year engineering students. The redesigned curriculum satisfies ABET and HLC accreditation requirements while also keeping our students on the usual 4-year trajectory for an engineering degree. The studio teaching approach in physics instruction, or "studio physics", was pioneered by the Rensselaer Physics Education Group in the 1990s as an innovative method to improve student engagement and conceptual understanding in physics [38]. This approach integrates traditional lectures with laboratory experiments, hands-on activities, and computer simulations, all within a technology-enhanced environment. By combining these elements, studio physics creates a more interactive and collaborative learning atmosphere. One defining characteristic of this approach is the reduction of lecture time, allowing for the incorporation of student-centered active learning strategies. These strategies emphasize peer-to-peer collaboration, problem-solving, and real-time feedback from instructors, fostering deeper learning and higher levels of student-instructor interaction [39]. This instructional model has demonstrated considerable effectiveness across various institutions, showing significant improvements in student retention, conceptual understanding, and performance compared to traditional lecture-based instruction [39-40].

Traditionally, even studio-style courses in STEM disciplines are taught separately, often in multiple semesters, leaving students with the burden of synthesizing knowledge across courses. Studies show that this separation frequently results in low knowledge retention rates and diminished ability to apply concepts in real-world engineering contexts [41]. Our project plan seeks to remedy this deficiency by adopting an interdisciplinary curriculum using a modified introductory physics sequence as the foundation for the integrated first-year curriculum. Math instruction will be provided using content aligned with these physics topics. Our existing engineering mathematics course, modeled along that created at Wright State [42], will provide some real-world engineering problem-solving contexts for the integrated curriculum.

A team-teaching approach will be implemented with engineering, physics, and mathematics instructors trained in the studio model collaborating in curricular design, assessments and instruction. Introducing essential prerequisite and co-requisite concepts in physics and mathematics alongside engineering topics would help students see the relevance of theoretical knowledge to practical engineering problems and enhance their ability to transfer this knowledge across contexts [43-44]. Collaborative instruction models such as this have been shown to improve learning outcomes for students from minoritized groups [45].

A variety of pedagogical techniques will be used, including problem-based learning, multi-week projects, inquiry-based learning, and group work. The integrated classes will meet in two- or three-hour blocks multiple times a week, not only to satisfy credit/contact-hour requirements, but also to allow for longer and more in-depth interdisciplinary collaborative sessions. A key principle of an equity-based pedagogical approach is to allow for a self-paced approach to learning. We propose to accomplish this through modular instruction that is provided both in-person and online, with tangible goals to help students assess their progress in achieving the relevant competencies [7] by the end of the first year.

C: Reorganization of Math, Physics and Engineering Curricula

A significant priority in our redesign is the examination and modification of the course content, sequence of topics, and depth of coverage in physics and math curricula. The challenges of the calculus sequence for engineering students are well-known, often acting to filter students out of the pipeline and derailing many engineering career aspirations [46-47]. Numerous "calculus reform" efforts have focused on improving teaching methods, contextualizing topics, and integrating applications but, in the main, math curricula have largely remained unchanged. Efforts like the Wright State Model [42] have successfully reduced dropout rates, but the **Engineering Mindset Report** [5] marks a significant shift by questioning not just pedagogy but also the content, order, and necessity of topics in the calculus sequence.

The traditional math sequence has two key flaws: it introduces theory-heavy topics like limits before students are mathematically mature enough to grasp them, and it doesn't align with the timing of when topics are needed in science or engineering courses. For instance, vectors are essential early in physics but aren't taught until multivariable calculus, while antiderivatives, crucial for understanding motion, are introduced late in Calculus 1 or even Calculus 2.
To address this, our math curriculum uses a just-in-time approach [48], delaying topics until they are needed in physics or engineering. For instance, limits and continuity will focus on intuitive concepts tied to average and instantaneous velocity in physics. Antiderivatives of simple functions will be introduced early for use in physics, while sequences and series will be postponed until Signals and Systems, and Laplace transforms until the Controls course.
Our approach to the Physics curriculum is based on integration of typically separate topics taught in introductory physics. For example, real-world engineering problems rarely mimic the separation of linear and angular motion concepts, or forces and energy principles in mechanics and electromagnetism. Instruction in key concepts in mechanics and electromagnetism are combined in the context of engineering projects to highlight their conceptual similarities. These similarities will be explored through carefully structured worksheets, fostering deeper conceptual understanding, and later applied to hands-on projects, enabling students to witness the interconnectedness between various disciplines and apply lessons learned in class to real-world challenges.

Our goal is to bridge the gap between the principles of physics and mathematics that students learn and the complex real-world design challenges they will face as engineers. Students will be exposed to engineering design challenges not only as technical issues but also through the lens of their social, ethical, economic, and human dimensions. By integrating Design Thinking [49] principles—such as empathy, problem identification, idea generation, and prototyping—with the concepts of Design Justice [50-51], we aim to provide a problem-solving experience that closely mirrors the multifaceted nature of real-world engineering challenges.

D: Student Recruitment and Onboarding

Our project aims to disrupt the inequitable models of recruitment and create new strategies that center equity and extend opportunities to students who have demonstrated perseverance and resilience in the face of systemic challenges. The traditional model of university admissions has focused on recruiting college-ready students instead of creating student-ready programs [21]. This has led to the exclusion of motivated students from underserved schools, particularly those with limited access to advanced STEM coursework or resources.

The project team includes a recruitment sub-committee which includes faculty, staff and community-liaisons with planned efforts to reach out and recruit from various communities, many of which reflect the demographics of the region in which the university is located. As mentioned earlier, the college and the university have multiple well-established equity-based initiatives with local high schools in the area. These programs, which are ongoing throughout the year, have allowed our faculty to partner with local K-12 teachers, counselors and coaches who lead their schools in non-traditional STEM pathways through high school level engineering-focused courses and extra-curricular programs (such as First Robotics). These existing partnerships will help us identify a cohort of students who evidence high levels of motivation and interest in engineering but may not have the requisite qualifications through standardized tests and GPAs that typically form the basis for admission to engineering programs. By fostering partnerships with local schools and community organizations, we aim to create pathways that reflect our commitment to equity and empower motivated students to succeed in engineering.

Existing university structures, partially funded by previous NIH and NSF grants, will help us in onboarding these students to the university environment as well as the freshman engineering class by incorporating a comprehensive range of support systems that address students' needs and foster a sense of community both in and beyond the classroom. Leveraging students' strengths and providing tailored support have been shown by similar initiatives [52] to be effective in diversifying STEM fields. Early intervention and support systems have been shown to foster students' science identity [53] while celebrating their various other intersectional identities. Within the classroom, we plan to implement a Learning Assistant (LA) program to provide student-centered support. These LAs, trained in pedagogy, will join the instructional team to enhance the studio learning environment by facilitating peer-to-peer interactions and supporting active learning. Outside the classroom, mentorship networks will be established to connect first-year students with upper-level peers, faculty, and staff. These mentorships aim to create an inclusive community where students can navigate academic challenges, celebrate diverse perspectives, and grow both personally and professionally.

At the institutional level, the University of Detroit Mercy has introduced an equity-focused faculty search process, which includes a Search Advocate [54] to minimize biases, implicit and explicit, throughout recruitment and retention. Expanding on this model, our project will incorporate a Student Advocate who will guide decisions and initiatives to prioritize equity and inclusivity in the recruitment, onboarding and mentorship of these students.

In addition, campus resources such as the Office of Equal Opportunity, the Student Success Center, the Office of Diversity, Equity & Inclusion, and the Center for Excellence in Teaching and Learning will collaborate with the project team. These offices will help assess and refine initiatives to ensure they are both equitable and effective, supporting an inclusive culture that benefits all students.

E: Institutional Support

The university's president has committed support for this project through an innovation fund that is funding the launch of the first-year pilot. This demonstrates institutional commitment at the highest level. Ensuring the success of these programs and reinforcing our commitment to equity requires alignment and dedication from all levels of the institution. Our diverse, multi-disciplinary project team is comprised of five major sub-committees: curriculum redesign, recruitment and admission, community & industry partnerships, student support and equity advocacy, and project assessment and accreditation. The curriculum design sub-committee and the ensuing instructional team have expertise in pedagogy, but they will be further trained in the different facets of our proposed initiative through the College's NIH-funded Institutional Development program. The various sub-committees will continue to work collaboratively to develop, implement, and assess this transformative initiative. The assessment sub-committee will gauge and analyze the effectiveness of the utilized approaches and suggest further modifications to center equity and inclusivity in our efforts. The expected launch and initial offering of the freshman year pilot program is being planned for the Fall of 2026. The project team will be closely working with the registrar and university administration to finalize faculty workloads and internal processes approvals.

F: Other Important Considerations

Apart from the key items discussed earlier, several key aspects of the program are still being finalized, including class size, faculty workload, and policies for students with transfer credits or advanced coursework. For the initial pilot, class sizes will be limited to 10-15 students. The existing engineering program will continue undisturbed, serving traditionally recruited students, while the proposed program will act as an alternative pathway. Although the pilot is designed with Universal Design for Learning practices to ensure flexibility, students with advanced credits will be directed to the traditional pathway during the launch year. After the initial offering, the pilot program will undergo assessment and adaptation to better serve all students, including those typically attracted to traditional pathways.

Faculty credit allocation will reflect contributions to contact hours, with the parent course combining credits from multiple courses. For the three studio instructors, this will count as one course each, though the exact allocation is still being negotiated with the administration.

Conclusions

Systemic barriers and inequitable engineering admission and retention practices constitute a national exclusionary and unjust system that our proposed project aims to transform. By emphasizing equity, flexibility, and inclusive support structures, we aim to transform the academic ecosystem and many of its accepted practices to create pathways into engineering that are accessible to all students, particularly those from marginalized and underserved backgrounds. Simultaneously, we will align outcomes with the evolving needs of industry, equipping students to thrive in a dynamic and diverse workforce. The demand for highly qualified workers is high, but the supply for this demand has been hindered by the exclusion of a large population of students who have the potential to make excellent engineers.

Engineering needs an equity-centered focus to become the transformational field that it aspires to be. Our proposed programs will train our faculty and students on inequities and biases that seep into the design of products and their effect on different populations and society at large. Increasing the representation of historically marginalized populations in the engineering pipeline and into the workforce is crucial in creating a more equitable future for all people.

VI: Acknowledgements

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References

[1] "Transforming Undergraduate Engineering Education (TUEE), Parts I-IV," *ASEE-NSF Workshop Report*. https://tuee.asee.org/about/. [Accessed: Jan. 14, 2025].

[2] "New Vision for Education: Unlocking the Potential of Technology," World Economic Forum, 2015. https://widgets.weforum.org/nve-2015/. [Accessed: Jan. 14, 2025].

[3] "The Future of Jobs Report 2018", World Economic Forum, 2018. https://www.weforum.org/reports/the-future-of-jobs-report-2018. [Accessed: Jan. 14, 2025].

[4] R. Graham, "The Global State of the Art in Engineering Education," MIT Report, Mar. 2018. https://www.rhgraham.org/resources/Global-state-of-the-art-in-engineering-education---March-2018.pdf. [Accessed: Jan. 14, 2025].

[5] The Engineering Mindset Report: The Vision for Change in Undergraduate Engineering and Engineering Technology Education, ASEE, 2024, https://mindset.ASEE.org. [Accessed: Jan. 14, 2025].

[6] S. Das, D. Kleinke, and D. Pistrui, "Reimagining engineering education: does Industry 4.0 need Education 4.0?," ASEE Annual Conference, Jun. 2020, Montreal, CA.

[7] D. Pistrui, D. Kleinke, and S. Das, "The industry 4.0 talent pipeline: a generational overview of the professional competencies, motivational factors & behavioral styles of the workforce," ASEE Annual Conference, Jun. 2020, Montreal, CA.

[8] D. Pistrui, J. Layer, and S. Dietrich, "Mapping the behaviors, motives and professional competencies of entrepreneurially minded engineers in theory and practice: an empirical investigation," *The Journal of Engineering Entrepreneurship*, ASEE Special Issue, vol. 4, no. 1, pp. 39-54, 2013.

[9] D. Pistrui, R. Bonnstetter, B. Bonnstetter, and C. Fry, "Creating, educating and assessing a new class of entrepreneurial minded engineers," *The Journal of Engineering Entrepreneurship*, vol. 2, no. 2, pp. 1-14, 2011.

[10] D. Pistrui, N. Rayess, R. Bonnstetter, and E. Gehrig, "Creating data-driven undergraduate student engineering typologies to shape the future of work," *American Society of Engineering Educators*, 128th Annual Conference Proceeding, 2021.

[11] M. Estrada, M. Burnett, A. G. Campbell, P. B. Campbell, and W. F. Denetclaw, "Improving underrepresented minority student persistence in STEM," CBE-Life Sciences Education, vol. 15, no. 3, es5, 2016.

[12] D. Pistrui, D. Kleinke, and S. Das, "The third path: a new approach to industry-based undergraduate engineering and technical education in the United States," ASEE Annual Conference, Jun. 2022, Minneapolis, MN.

[13] D. Kleinke, S. Das, and D. Pistrui, "Reimagining engineering education programs to fill the talent pipeline," American Society for Engineering Management 2022 International Annual Conference and 43rd Annual Meeting, Oct. 2022.

[14] I. Petrick, Senior Director, Industrial Innovation: Intel Internet of Things Groups, "How are IIoT and digitization changing the manufacturing landscape," Guest Lecture Series, Purdue University, Exploring the Applied Technologies, Jun. 2021.

[15] D. S. Stanley and V. Aggarwal, "Impact of disruptive technology on human resource management practices," Int. J. Bus. Continuity Risk Manag., vol. 9, no. 4, pp. 350-361, 2019; S. Fang, A. Moreno Brenes, and S. Brusoni, "Technology intelligence and digitalization in the manufacturing industry," Res. Technol. Manag., vol. 66, no. 5, pp. 22-33, 2023; D. Bambe, "Disruption in manufacturing industry future of global workforce," Adv. Soc. Sci. Res. J., vol. 6, no. 11, pp. 357-385, 2019.

[16] K. M. DeGoede, "Competency based assessment in dynamics," in Proc. 2018 ASEE Annual Conf. Exposition, Salt Lake City, UT, Jun. 23-26, 2018.

[17] D. Clark and R. Talbert, *Grading for Growth*, Stylus Publishing, LLC, New York, NY, 2023.

[18] S. Das, D. Kleinke, D. Pistrui, and R. Bonnstetter, "Rules and procedures in academia: Do they help or hurt?" International Mechanical Engineering Congress and Exposition (IMECE 2023), Oct. 29-Nov. 2, 2023, New Orleans, LA.

[19] A. P. Carnevale, M. L. Fasules, M. C. Quinn, and K. P. Campbell, "Born to win, schooled to lose: Why equally talented students don't get equal chances to be all they can be," Georgetown University: Center on Education and the Workforce, 2019, https://cew.georgetown.edu/wp-content/uploads/FR-Born_to_win-schooled_to_lose.pdf. [Accessed: Dec. 20, 2024].

[20] T. B. McNair, E. M. Bensimon, and L. Malcom-Piqueux, *From equity talk to equity walk: Expanding practitioner knowledge for racial justice in higher education*, 2020.

[21] T. B. McNair, S. L. Albertine, M. A. Cooper, N. L. McDonald, and T. Major, *Becoming a student-ready college: A new culture of leadership for student success*, 2016.

[22] National Science Board, National Science Foundation, *Higher education in science and engineering: Science and engineering indicators 2022*, NSB-2022-3, Alexandria, VA, 2022, https://ncses.nsf.gov/pubs/nsb20223/; American Society for Engineering Education, *Profiles of engineering and engineering technology, 2023*, Washington, DC, 2024, https://ira.asee.org/wp-content/uploads/2024/12/Engineering-Engineering-Technology-By-the-Numbers-2023-1-combined.pdf. [Accessed: Jan. 14, 2025].

[23] UNICEF, *Inclusive education*. https://www.unicef.org/education/inclusive-education. [Accessed: Jan. 14, 2025].

[24] K. M. Cooper, S. E. Brownell, and K. Knoespel, “Multiple-choice exams: An obstacle for higher-level thinking in introductory science classes,” *CBE-Life Sci. Ed.*, vol. 15, no. 4, art. no. ar53, 2016.

[25] T. Holloman, W. C. Lee, J.S. London, A.B. Halkiyo, G. Jew, and B.A. Watford, “A historical and policy perspective on broadening participation in STEM: Insights from national reports (1974-2016),” in *2018 CoNECD-The Collaborative Network for Engineering and Computing Diversity Conference*, 2018.

[26] F. A. Hrabowski III, “Broadening participation in American higher education—A special focus on the underrepresentation of African Americans in STEM disciplines,” *The Journal of Negro Education*, vol. 87, no. 2, pp. 99-109, 2018.

[27] T. J. Oyana, S.J. Garcia, J.A. Haegele, T.L. Hawthorne, J. Morgan, and N.J. Young, “Nurturing diversity in STEM fields through geography: The past, the present, and the future,” *J. of STEM Education: Innovations & Res.*, vol. 16, no. 2, pp. 20-29, 2015.

[28] M. Loftus, “Untapped potential,” *ASEE Prism*, vol. 18, no. 2, p. 52, 2008.

[29] D. Peggy *et al.*, “Closing the gaps and filling the STEM pipeline: A multidisciplinary approach,” *J. Sci. Educ. Technol.*, vol. 25, no. 4, pp. 682–695, 2016.

[30] M. O. McGee, “Interrogating structural racism in STEM higher education,” *Educ. Res.*, vol. 49, no. 9, pp. 633–644, 2020.

[31] National Science Foundation, *Women, minorities, and persons with disabilities in science and engineering*. https://ncses.nsf.gov/pubs/nsf19304/. [Accessed: Jan. 14, 2025].

[32] E. Seymour and N. M. Hewitt, *Talking about leaving: Why undergraduates leave the sciences*. Boulder, CO: Westview Press, 1997.

[33] B. Coley and J. Holly, “Starting with the promises: moving from inspirational words to institutional action in addressing systemic racism,” in *2021 IEEE Frontiers in Education Conference (FIE)*, IEEE, 2021, pp. 1-4.

[34] C.A. Berry, A. Bowden, M.F. Cox, T.N. Reid, and L.L. Long, “Black in engineering: how the social justice efforts of Black academics affect change,” in *2021 ASEE Virtual Annual Conference Content Access*, 2021.

[35] E. Armstrong and L. Hamilton, *The inequality machine: how college divides us*, Mariner Books, 2021.

[36] "BUilding Infrastructure Leading to Diversity," National Institutes of Health (NIH) Diversity Program Consortium. https://diversityprogramconsortium.org/dpc/consortium-members/build. [Accessed: Jan. 14, 2025].

[37] Note: this reference is hidden to protect the integrity of the double-blind process. It will be included in the final version if the paper is accepted for ASEE 2025.

[38] J. M. Wilson, "The CUPLE physics studio," *The Physics Teacher*, vol. 32, no. 9, pp. 518-523, 1994.

[39] R. J. Beichner, J. M. Saul, D. S. Abbott, J. J. Morse, D. L. Deardorff, R. J. Allain, S. W. Bonham, M. H. Dancy, and J. S. Risley, "The Student-Centered Activities for Large Enrollment Undergraduate Programs (SCALE-UP) Project," *Research-Based Reform of University Physics*, 2007.

[40] K. Cummings, J. Marx, R. Thornton, and D. Kuhl, "Evaluating innovations in studio physics," *Am. J. Phys.*, vol. 67, no. S1, pp. S38–S44, 1999.

[41] M. Prince, "Does active learning work? A review of the research," *J. Eng. Educ.*, vol. 93, no. 3, pp. 223–231, 2004.

[42] Wright State Model for Engineering Mathematics. https://engineering-computer-science.wright.edu/research/the-wright-state-model-for-engineering-mathematics-education. [Accessed: Jan. 14, 2025].

[43] M. J. Prince and R. M. Felder, "Inductive teaching and learning methods: Definitions, comparisons, and research bases," *Journal of Engineering Education*, vol. 95, no. 2, pp. 123–138, 2006.

[44] E. Brewe, L. Kramer, and G. E. O'Brien, "Modeling instruction: Positive attitudinal shifts in introductory physics measured with CLASS," *Physical Review Special Topics - Physics Education Research*, vol. 6, no. 1, p. 010106, 2010.

[45] B. Van Dusen and J. Nissen, "Systemic inequities in introductory physics courses: The impacts of learning assistants," *Proceedings of the 2017 Physics Education Research Conference*, pp. 400–403, 2018.

[46] D. Bressoud, E. Johnston, C. Murphy, K. Rhea, J. Williams, and P. Zorn, "The calculus sequence," *Mathematical Association of America*, 2024. https://maa.org/wp-content/uploads/2024/06/CalculusCASGReportFinal.pdf. [Accessed: Dec. 20, 2024].

[47] B. S. W. Schröder, "Rearranging the calculus sequence to better serve its partner disciplines," *The American Mathematical Monthly*, vol. 113, no. 7, pp. 628–636, 2006. https://doi.org/10.2307/27642005. [Accessed: Dec. 20, 2024].

[48] G. Novak, E. T. Patterson, A. D. Gavrin, and W. Christian, *Just-In-Time Teaching: Blending Active Learning with Web Technology*, Prentice Hall, 1999.

[49] "Design Thinking," https://www.ideou.com/pages/design-thinking?srsltid=AfmBOoq0AnwpRk7WHT1426G6uhw7ISZHAYS_PuIZGba1GXEtXtCHue4U. [Accessed: Jan. 14, 2025].

[50] S. Costanza-Chock, *Design justice: Community-led practices to build the worlds we need*, The MIT Press, 2020.

[51] Design Justice Network, "Design Justice," https://designjustice.org. [Accessed: Jan. 14, 2025].

[52] K. I. Matón and F. A. Hrabowski, "Increasing the number of African American PhDs in the sciences and engineering: A strengths-based approach," *American Psychologist*, vol. 59, no. 6, pp. 547-556, 2004.

[53] M. K. Eagan, A. L. Romero, and S. Zhong, "BUILDing an early advantage: An examination of the role of strategic interventions in developing first-year undergraduate students' science identity," *Res. High Educ.*, vol. 65, pp. 181–207, 2024.

[54] "OSU Search Advocate Program," *OSU Search Advocate Program*. https://searchadvocate.oregonstate.edu/. [Accessed: Jan. 14, 2025].