Diverse and Inclusive Learning and Working Environments

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**Abstract.** This chapter aims to equip leaders in engineering with the tools to create a more diverse, equitable, and inclusive education and industry. This chapter first highlights issues experienced by various marginalized groups due to curricular designs and tangential academic work environments. The topics covered include creating a more inclusive environment for women through FemTech in the United Kingdom, decolonizing the curriculum to focus on problems relevant to students’ local context in South Africa, and advancing Diversity, Equity, and Inclusion (DEI) alongside professional organizations through inclusive leadership in the United States of America. Next, the chapter documents three cases that aim to provide examples of strategies to manage DEI problems by tackling student and educator barriers to belonging and continuously building more diverse and inclusive systems and teams. Overall, this chapter shares ways educators and leaders can learn from each other and create a more sustainable and inclusive setting for learning and working environments.

**Keywords:** Curriculum Design, Problem-Based Learning, Decolonization, FemTech, Advancing DEI through Inclusive Leadership

1. Introduction

## “Leaders need to design organizations [and classrooms] that equitably meet the needs of their talent. And this exciting movement toward building tomorrow’s equitable organization is dependent on a new type of leader: the inclusive leader [1, p. 6].”

When seeking excellence through diversity, equity, and inclusion (DEI) in engineering education, we face several challenges presented by structural issues that materialize as institutional and interpersonal messages that are normalized in our policies, practices, programs, and cultures [2]. However, we must confront these challenges through the global exchange of insights to inform who we teach, how we teach, and what we teach in engineering education [3]. For example, actionable dialogues may involve diversifying the composition of students and faculty, building inclusive learning and working environments wherein students and faculty can thrive, implementing curricula that students can relate to, building and implementing equitable assessments, and teaching the importance of inclusive design and the social responsibility of engineering solutions. Consequently, this chapter describes multiple efforts to cultivate diversity and inclusion in learning and working environments in engineering education.

This chapter aims to equip leaders with new perspectives that will, in some areas, help them work toward building an inclusive classroom and team. We emphasize the importance of creating welcoming environments for staff and students to advance diversity, equity, and inclusion in engineering education and practice. Engineering educators, practitioners, and leaders will benefit from extending their understanding of some of the rewards and challenges faced by students, educators, and professional development leaders in engineering education, as well as gaining inspiration on how to resolve them. Likewise, those seeking to influence policymakers or funding agencies will find themselves armed with evidence-based insights to lead change in their learning and working environments through the perspectives of a diverse group of authors and leaders in their respective positions and communities.

1. Literature Review

This literature review situates each case study’s issue and suggests some alternative approaches to address barriers to prioritizing inclusion in learning and working environments. We describe how FemTech, and decolonization have been used to create and foster inclusive and equitable learning environments. We then explore how professional associations leverage their position as national and international bodies to advance DEI in STEM fields.

* 1. Inclusive Learning Environments

**Integrating FemTech into Curricula to Increase Women’s Sense of Belonging in Engineering.** Traditionally, engineering education and practice have focused on engineers as problem solvers [4], lending it well to current trends in authentic, contextual, and project-based learning. For students to succeed within higher education, we cannot solely focus on what they are taught, but also on how they learn. Male and Bennett’s research finds that students need to understand what engineering is and to envision themselves as future engineers [5]. This recognition is particularly challenging for marginalized students who lack role models for framing that future and relatable context within their learning.

The field of engineering struggles with recruiting and retaining marginalized students due to a lack of belonging within education and industry. One group historically impacted is women of all backgrounds. Consequently, this lack of representation leads to many issues with accepted standard designs and processes that are not suitable for women, contributing to a greater gender disparity [6], [7]. For example, snow clearance schedules in Sweden prioritized roads over pavements, which ultimately benefited male commuter routes, leaving women at higher risk of hospitalization due to using pavements for their commutes and ‘school-runs’ [7]. While this is not always the case, many products addressing this gap are often related to the rising FemTech industry.

FemTech focuses on products designed for healthcare related to female physiology; design solutions ranging from menstrual product manufacture and fertility trackers to breast pumps and vibrators are considered FemTech. This industry encompasses a wide range of products to support various individuals. It targets the needs of cisgender and transgender women, some transgender men, asexual and non-binary individuals, as well as pre-teens through to the post-menopause age range. In an education setting, FemTech enables students to engage in authentic, contextual project-based learning using user-centered design [8], with users focusing on the spectrum of people as described above. This approach allows students to develop technical skills within a meaningful context alongside developing their sense of identity and self, passing the threshold into thinking of themselves as engineers.

**Decolonizing the Engineering Curricula.** Colonialism, which refers to the geographical, political, judicial, and economic subjugation of different parts of the world by the European imperial powers, ended with nations gaining independence. However, coloniality outlived the end of colonization, i.e., the hierarchies imposed in the minds and systems of the then-colonized populations. As such, remnants of colonialism manifested in their governance structures, educational institutions, cultural patterns, and other day-to-day experiences [9].

Decolonization ends the imperial power’s territorial control over the erstwhile colonized territories, and the various racial, gender, sexual, religious, epistemic, and other hierarchies imposed on the previously colonized people [10]. As Smith [11] notes, it is “a long-term process involving the bureaucratic, cultural, linguistic and psychological divesting of colonial power” (p. 112).

Various scholars and activists worldwide have worked on decolonization over the last several decades. In the context of the academic curriculum, decolonization has been seen as a practice that challenges the Western conceptualizations of knowledge production and sharing while legitimizing other epistemic traditions [12]. Thus, the goal is to create a dialogue between different ways of knowing [13].

Decolonizing engineering education goes beyond creating a level playing field for diverse epistemic traditions. It also involves considering the developmental needs of erstwhile colonized societies and calls for the need to design locally relevant curricula to address these needs [14]. Moreover, decolonization also involves developing critical awareness among students and empowering them to work towards these needs, such as food security, healthcare, sanitation, water, etc. Furthermore, decolonization democratizes the curriculum by critically questioning the actors who are involved in producing knowledge [11], who is disseminating that knowledge [14], and who gets a say in implementing that knowledge for the betterment of people [15].

Additionally, scholarship on decolonization has also called for understanding the experiences of students from marginalized backgrounds and creating academic environments that are welcoming to all students. For example, in the South African context, Soudien [16] argues that the university setup can alienate students with forms of social and cultural capital that differ from middle-class and White students, which are often not recognized as valuable in traditional learning environments. Dube [17] and Motala et al. [18] highlight the linguistic barriers in learning when the language of instruction is not the same as the students’ primary language of communication. This linguistic barrier in teaching and learning poses a key challenge for students in several erstwhile colonies in Africa, Latin America, and the Indian subcontinent where languages such as English, French, Portuguese, and Spanish have replaced the local languages in academic settings. These issues highlight the need for incorporating strategies that are inclusive of alternate ways of knowing and students’ diverse linguistic backgrounds.

* 1. Inclusive Working Environments

**Advancing Diversity, Equity, and Inclusion Through Professional Organizations** National and international professional associations are membership networks that help advance the profession and empower professionals through various member services, such as professional development programs, education and outreach, and the distribution and exchange of scientific knowledge through publications and conferences [19]. Likewise, these associations are also situated to inform accreditation boards [20], and influence policy and legislation through advocacy [19], [20]. At the surface, some STEM professional associations have made strides to promote diversity, equity, and inclusion [20]. However, STEM professional associations are also plagued with issues pertaining to bias, discrimination, exclusion, and harassment of scientists and engineers based on their race and ethnicity, gender identity and sexual orientation [21], and disability. As a result, these associations have directly and indirectly reinforced exclusionary disciplinary norms, cultures, and values by ignoring misconduct and condoning the exclusion of people, through inaction and narrow framings of what counts and who belongs in STEM.

However, in recent decades and, for some, expedited in the wake of the #MeToo Movement and George Floyd’s murder, association staff, leaders, and volunteers have recognized how professional associations are in a prime position to transform the profession through shifts to policies and practices that center and intentionally include those historically and systemically excluded in STEM fields [20], [22]. For example, George Floyd’s murder made a global impact on the need for police reform and racial justice [23]. Likewise, the #MeToo movement served as a catalyst to address gender bias and sexual harassment in STEM. These collective actions to create a more diverse, equitable, inclusive, and just STEM profession often materialize through multiple structures, such as diversity focused conferences (e.g., CoNECD), diversity task forces [24], strategic STEM alliances [20], committees [25], commissions and divisions [26], amongst others. Similar to higher education institutions, these approaches are not mutually exclusive, meaning professional organizations may simultaneously implement multiple structures to support DEI work [27]. One recent contribution by a STEM alliance in the United States involved the development of an inclusive professional framework to provide professional associations with a lens to examine how they “support and hinder DEI aspirations and help set a foundation for lasting organizational change” [20, p. 2]. Otherwise, the sustainability of these professional associations is at risk of failure [28]. Together, these insights help ground a conversation about what it means to build and sustain diverse and inclusive teams charged with advancing diversity, equity, and inclusion in partnership with and through professional organizations.

1. Positionality

The authors of this chapter represent multiple facets of the engineering education ecosystem within the United Kingdom (UK) and the United States of America (USA). As such, we chose to disclose our positionalities as educators, researchers, students, and leaders to help the reader understand how we are positioned in relation to the chapter’s context. Each author reflected on a personal story to impart their commitment to advancing diversity, equity, and inclusion in our respective environments, core elements of our identity, and experiences of privilege and marginalization, and its influences on our work as educators and leaders. Lastly, we describe our connection to the case and how our positionality influences the selected cases presented in this chapter.

* 1. Agg

Agg was brought up in the UK and recalls a close and influential relationship with her grandfather; as an engineering hobbyist, he did not permit his granddaughter into his workshop due to tradition and fear of her being hurt. Agg’s decision to become an engineer came from a determination to stand beside him overhauling steam engines together. The journey has not been an easy one, though, experiencing a range of prejudicial barriers, such as being told by her grandfather’s acquaintances that she should not be studying engineering, as a woman could never amount to anything in that field. Working in construction, Agg’s line manager told her to crawl under a desk to plug his laptop in because she was wearing a skirt. She would be mistaken for the secretary in meetings with external stakeholders in their forties. On-site visits, she would walk into the shared office space of men in their twenties to find calendars of topless women on the wall. Things are improving, but the journey through engineering has provided Agg with little sense of belonging. Thus, she has endeavored to create one for the next generation of  women entering the engineering industry. She has done this through school outreach, creating training and support schemes in industry, and now as a student experience-focused lecturer in academia. Coming from a minoritized gender within engineering, she reflects upon her own experiences to develop more inclusive practices, especially for women in the field. Examples of inclusive practice include using anonymized live forums to create in-session discussions and questioning opportunities for large class teaching and teaching about methods for fostering inclusive teamwork prior to group assessments. This approach, though is limited by her cis-gender, middle-class, white, euro-centric lived experience, and thus she strongly values the diverse range of students, trainees, and colleagues she has had the privilege to work with through these engineering projects

* 1. Agrawal

Agrawal identifies as an upper-caste queer academic from India. He works at a university in the United States (US). He has previously worked in diverse national academic contexts, including South Africa and India. He has spent a significant part of his academic and professional journey studying curricular and pedagogical practices and the resulting student learning experiences. Additionally, he has worked with faculty members to help them adopt evidence-based and equitable teaching approaches in their classrooms.

Moving across national academic cultures has allowed him to experience privileges and disadvantages due to shifting identities. For example, being in a relatively privileged position in India, he first realized the importance of individual backgrounds based on caste, class, English competency, and rural versus urban upbringings in influencing academic success during his undergraduate studies. As a graduate student in the US, he was exposed to other facets of diversity and the systemic disadvantages experienced by different groups due to their identities through his first-hand experiences of being an immigrant.

As Agrawal moved to South Africa amid the #FeesMustFall movement aimed at improving students’ access to higher education, he realized that educators must design and facilitate inclusive learning environments for the success of underrepresented students. In addition to policy changes to reduce tuition and fees to broaden access for students from low socioeconomic backgrounds, efforts need to be made at the curricular and pedagogical levels to increase the relevance of the course material for students, which can lead to a deeper and more critical engagement with the concepts. As a result, Agrawal became interested in the ongoing debate on curricular transformation through decolonization. For Agrawal, decolonization of curricula refers to curricular changes to make learning more relevant to individuals from diverse backgrounds while developing their ability to critically reflect on their learning and life experiences. Additionally, decolonization allows for a greater community involvement through their engagement in the teaching and learning process.

* 1. McIntyre

McIntyre is a Black woman who grew up in a blended, middle-class family in eastern North Carolina. She is a proud Historically Black College and University (HBCU) alumna. Among her research interests, she is passionate about civic engagement in her local and professional community. Through service and mentorship, she has dedicated time to advancing undergraduate and graduate scholars in higher education and K-12 settings (e.g., primary and secondary education). Throughout her upbringing, she was aware of the educational and economic disparities for African American and Hispanic families because her mother and aunts were educators and leaders at Title I schools (e.g., a United States federal education program to support low-income students), so it was instilled at an early age to help and serve others, which laid the foundation of her commitment to educational equity and civic engagement. However, as a child, she did not make the connection or understand the implications of these inequities on the national and global underrepresentation of Black engineers. As she progressed in higher education and transitioned to a historically white institution, she became more conscious of systemic issues influencing what counts and who belongs in engineering education and the workforce.

Within engineering education, she has experienced how engineering education is siloed, in terms of where diversity, equity, and inclusion fit within the field. She values the importance of creating a culture where her colleagues and students feel empowered to contribute without negotiating who they are to establish a sense of belonging. She believes engineering education should recognize diversity, equity, and inclusion as central to its purpose and mission rather than sprinkled in as an afterthought. By centering on diversity, equity, and inclusion, engineering education can begin to address ways to create inclusive environments designed for all rather than just a few. However, this agenda must begin with strengthening the preparation of our engineering education professionals. These experiences drew her to join the ASEE Commission on Diversity, Equity, and Inclusion and collaborate with other dynamic educators and leaders to build a community of education professionals passionate about diversity, equity, and inclusion in engineering education.

* 1. Zou

Zou is a cisgender woman who is currently a final year student of Mechanical Engineering at Imperial College London. She grew up as a Chinese immigrant in Chile and has had the privilege to experience diverse educational systems and cultures in Chile, China, USA, and UK. She chose her current degree because it seemed like the logical choice to make given her interest. At school, she always performed better at STEM subjects and was more interested in application rather than theory. However, it was not until university that she understood the importance of female representation in engineering. At the start of her university studies, she viewed her degree as steppingstone to a stable work position, which were further enhanced while continuously being presented with traditional engineering examples related to construction and motorsports throughout her degree. She saw this as further proof that she was not made to be an engineer. However, this perspective changed when she worked on a FemTech literature review and designed a menstrual testing rig for her third-year projects. These projects exposed the lack of inclusion and consideration in many objects and processes used in our daily lives. Therefore, working on creating more women-centered designs provided her with a sense of need and value as an engineer. It highlighted the importance of having diverse engineers bring their lived experiences and advocate for more inclusive designs.

These inclusive projects allowed her to recognize a gap in the engineering industry that she can fill by working on women-centered projects that interest her. This new sense of belonging in the engineering industry allowed Zou to see herself as an engineer in training, and not just a woman studying engineering. Consequently, she has become interested in promoting more opportunities for students who do not fit the usual mold of an engineer and help them find a sense of belonging in the industry. However, she also recognizes the immense privilege she has had from encouraging mentors and economic circumstances that have allowed her to pursue her interests freely. Knowing that many students do not have this privilege drives her to take advantage of her fortunate position. Instead, she uses her platform to inform faculty and administrators about the importance of integrating inclusive projects into the curriculum, so academics can offer them, and students can be empowered to ask for them.

1. Leading by Example

In the following three subsections, three cases are presented to demonstrate how engineering educators can begin to consider how to build diverse and inclusive learning and working environments. These cases were selected based on previous and current experiences of the authors leading efforts to advance diversity, equity, and inclusion (DEI) through curriculum reform and professional development efforts. Consequently, these cases uncover insights about integrating FemTech into a Mechanical Engineering curriculum in the UK to improve the retention of women in engineering, decolonizing an engineering curriculum in South Africa to address inequities in engineering education, and building and sustaining diverse and inclusive remote teams in the USA designed to support a community of engineering educators and practitioners committed to learning how to advance diversity, equity, and inclusion in their research, teaching, service, and leadership.

* 1. Case Study 1: Integrating FemTech into a Mechanical Engineering Curriculum

**Background** Building upon the findings of Bennett and Male’s study of possible selves [5], engineering undergraduate students need to see themselves as engineers to achieve highly in their studies. However, many engineering degrees are based on the science behind the engineering fundamentals, giving a ‘pure’, theoretical, and person-agnostic approach to education. Within this pedagogical approach, it’s difficult for our students to visualize (or recognize) themselves as applied engineers. In the few cases where specific persons are mentioned, such as Bernoulli or Pythagoras, they are almost all white European men. To give context to the engineering science, mechanical engineering syllabi historically tend to focus on motorsports, aviation, and other modes of transportation. While for some students this content is highly engaging and exciting, for others it does not align with their values or with their ability to identify with a possible future self within engineering. This lack of relatable or value aligned  content is therefore a potential reason why our female students progress into engineering careers at a lower rate than their male counterparts. It may also be a cause for the lack of recruitment and retention efforts designed to support diverse cohorts, particularly women, in engineering education and subsequent careers.

How can we, as academics, adapt our curricula to provide an inclusive environment, that enables a more diverse range of students to imagine themselves achieving self-actualization within the engineering sector? Huge efforts are being made across the sector to decolonize engineering science, provide more examples of role models, and provide greater visibility of the science and research conducted beyond the traditional euro-centric teachings. However, while important, this work is constrained by the historical and current biases in access to education, funds, and publication. To remove these limitations, we must recognize the possibilities within teaching and learning to transition from teaching pure theoretical concepts to pedagogical innovations that center on the applying science where we can situate learning within a  human-centered context.

Consequently, this case study utilizes project-based learning opportunities, which already exist within the UK curriculum, and enhances their inclusivity by introducing FemTech themed projects. FemTech is a relatively new term that describes technologies focused on women’s health. Examples range from modern and high-tech, such as menstrual tracker apps and pelvic floor exercisers, to longer-standing but underdeveloped designs, such as breast pumps and the speculum, used for gynecological procedures. These project-based modules are open-ended and offer both students and staff the opportunity to innovate.

This ‘new space’ in which projects exist within engineering education allows us to work on research and design areas that have not previously been explored in depth. Traditionally, this space has enabled students and their supervisors to extend knowledge, or identify knowledge gaps, in areas of long-standing research. On the FemTech inclusion program, however, we are instead enabling students to work on areas with little prior research. In addition to giving female-specific subject areas, this gives students the benefit of emulating the difficulties and excitement experienced by small startup businesses and inventors in new technologies. Lastly, the liminal nature of innovative project work aligns closely with the liminal space required for the transformational nature of threshold concepts, allowing students to see themselves and their education differently.

At Imperial College London we have introduced FemTech projects across three different project formats:

**Table 1.** FemTech Project Examples

|  |  |  |  |
| --- | --- | --- | --- |
| Project Type | Type Description | Project Description | Participants |
| LRP | Literature Review Project30-page report covering 30-50 references3rd year students 5 ECTS / 2.5 US Credits | ‘The Rise of FemTech’ - student to define FemTech and analyze its growing usage and impact in education. | 1 F |
| ‘Testing methods for menstrual products’ - investigating publications on this topic and drawing comparisons to related research such as testing incontinence products.  | 1 M |
| DMT | Design Make TestGroup project with Sub-assemblies teams of ~4 contributing to an overall ‘super-project’ team3rd year students20 ECTS / 10 US Credits | ‘Menstrual Product Testing Rig’ students created a replica fluid and injection system, an artificial vagina with heating system and a biomimetic chassis with sensors. | 7 M5 F |
| ‘Manufacture of Banana Fiber based Menstrual Products’ students created a fiber cutting system and a fiber carding system. | 5 M3 F |
| FYP | Final Year Project12,000-word report as main assessment4th year students25 ECTS / 12.5 US Credits | ‘Banana Fiber-Based Sanitary Pad Project for Women in Rural Rwandan Villages’ student researched manufacturing methods for a biodegradable plant-based waterproof layer for menstrual pads. | 1 F |

The menstrual product testing rig ‘DMT’ and the biodegradable waterproof menstrual pad layer ‘FYP’ have won departmental and university-level awards within one year of launching the project, demonstrating the individual and academic value of the projects. Anecdotal outcomes suggest that students have gained a broader awareness of possible engineering roles, industries, and applications, such as menstrual product testing. In addition, these projects have provided students with a clear demonstration of the potential impact engineering can have on women’s health and social justice more broadly. Many students indicated a renewed interest in remaining in the engineering sector, citing their projects as the reason for seeing themselves as future engineers. The projects have also catalyzed more widespread conversation and change; for example, staff members who second-assessed project reports stated an increased awareness of the need for gender-disaggregated data and specific female-centered projects within biomedical engineering research. Another example includes the development of a national menstrual tech collaborative platform for academics in the UK, given the lack of currently available published papers and other formal knowledge sharing on this topic.

 At the department’s end-of-year showcase, the products and posters generated by the FemTech projects were amongst the most popular stands at the exhibitions. Fellow students, staff, and the public were all highly interested in learning more about these new research areas, illuminating the positive impact we engineers can have in changing the conversation and generating new interest in the engineering sector. However, FemTech has limitations because most publications about FemTech projects and research focus on the experiences and needs of English-speaking, white cis women [29], though this has not been the experience within our setting where students on the projects had a roughly even split between male and female, and where white students were in the minority. Further work is required to understand the impact of FemTech projects in undergraduate engineering education. However, in this case, students have indicated positive outcomes, not solely for white female students.

Taking our Chinese-Chilean student author’s own experience into account, she informs us how the FemTech project has impacted her engineering identity.

“The most impactful factor that has made me consider a future in engineering is feeling like I am able to make a difference and fill a space in the industry that is currently lacking. Seeing the lack of inclusivity for women in many designs and products has shown me that more diverse engineering groups are needed to create more inclusive products. And the only way to make a lasting change is to stay within the industry and push for more inclusivity. As an engineer in training, I am already in a privileged position to impact others’ lives and create opportunities for more inclusivity. Having this realization has sparked a feeling of belonging and responsibility to stay in the industry and make the changes I want to see.”

As engineering academics, we know that engineers should be able to solve problems and identify them in various contexts, particularly noting how there are many areas of inequity in women’s health that engineering can help reduce. Consequently, FemTech is a force for good in reducing societal inequities while simultaneously creating an inclusive, diverse, and supportive learning environment.

* 1. Case Study 2: Decolonizing the engineering curriculum in South Africa

**Background** The student-led protests starting in 2015 under the umbrellas of #RhodesMustFall and #FeesMustFall created a sense of urgency for universities to address the different forms of inequities in South African higher education [30]. These protests started at the University of Cape Town with demands to take down the statue of Cecil Rhodes on campus. Upon the success of the #RhodesMustFall campaign, the protests soon grew nationwide under the banner of #FeesMustFall. As the name suggests, the latter protests aimed to bring the attention of the government and the university authorities to the rising costs of higher education, making it exclusionary for people from lower economic strata. In addition, these protests also aimed to address other forms of inequities at the universities, including discrimination based on race, gender, and other factors, and to decolonize the curricula to make them relevant for a larger body of students [14].

While responding to this issue, several universities started transforming their curricula to make them more equitable [30]. One such initiative was adopted at our case site, a large, research-focused, and historically English-medium university. The Department of Chemical Engineering replaced its existing second-year undergraduate course project.

In the sections below, we first describe the new course project, highlighting the changes made to the existing course project. Then, we discuss how the course project met the goals of decolonization. Quotes from the interviews conducted with the course lecturer and the course tutor who was involved in designing and implementing the project, along with excerpts from project tasks given to students, are included as evidence. Interview data were also collected from students to capture their experience of the project. However, the analysis of the student interviews is beyond the scope of this chapter. These data were collected following the human subjects approval from the Ethics-in-Research Committee at the data collection site. We encourage the readers to refer to other publications from this project [31], [32] for project design and implementation details.

**Design of the new project.** The undergraduate chemical engineering curriculum requires students to engage in a semester-long project during the second year of the degree. Prior to 2018, the students were expected to complete a project that involved the design of a large petrochemical plant. Specifically, students were asked to create a plan to synthesize a precursor to produce polymers using refinery products. The learning goal for students was to execute the different aspects of designing plants for large industrial processes and the key factor driving this design was the commercial concerns of making a profit for the manufacturing plant. There was little emphasis on the social or the environmental aspects of engineering except when students were asked to analyze the potential impacts of the petrochemical plant on the nearby surroundings in case of a catastrophic event. However, since the project was situated in the context of a large-scale industrial plant, the students were unfamiliar with the problem’s context.

To rectify this issue concerning students’ unfamiliarity with the problem’s context, the department introduced a new course project in 2019. This new project required students to design an anaerobic digester in an informal urban setting located in the peripheries of the city where the university is located. The feed for the digester included waste generated from people’s day-to-day activities, including waste from slaughtering animals, cooking food, gardening, and human excreta.

In addition to shifting the context, the new project incorporated an asset-based community-driven approach. An asset-based approach necessitates that the students consider the existing resources that a community already has and then work closely and collaboratively with community members to plan initiatives to develop the community [33]. This approach is a departure from a more commonly adopted needs-based engineering practice that looks at a community from a deficit standpoint to identify its needs and then designs solutions to fulfill them with little to no input from the community.

Besides adopting an asset-based mindset, the students were required to work with a community-based organization (CBO) that was seen as the driver of the project while the students acted as consultants. The students in the role of consultants sought feedback from the CBO on their progress, which was evaluated from the community’s needs and its potential impact on the people. The CBO that the students engaged with was role-played by the course instructor and the course tutor acted as the member of the CBO. We used this approach due to the logistical and financial constraints of hiring a CBO on a long-term basis. However, the instructor and the tutor provided a reasonable substitute for CBO members, given their experiences of living in informal communities and being exposed to the literature on the lives of people in these communities.

It is important to note that the new project did consider the commercial concerns related to the economic gains. However, the commercial concerns were addressed simultaneously with the proposed design’s social and environmental impacts, specifically the contributions by and the resulting benefits to the community.

**New Project and Decolonization Goals.** There were several ways in which this new community-driven course project met our goal to decolonize the curriculum. The first and most important way in which the project aligned with decolonization aims was to move the context of learning from large industrial plants to the local community. As the course tutor reflected on the experience of redesigning the project:

The [project] scope remained the same in the case of the key result areas with the experience students do get, but I think the concept changed. [Thus, the new project addressed] that issue of decolonizing science and trying to introduce concepts to students which were Africa-based, or community based.

As the context of learning changed to a place and more familiar project, it was easier for students, especially those from underprivileged backgrounds to better relate to the course.

To what extent ... is a portion of the class that comes from socially disadvantaged backgrounds, from the types of backgrounds we want to benefit from this, it seemed to me there were people in [the] group that had that relation, emotional or direct through family where they had personal experiences to that. (Course Lecturer)

Second, this project increased stakeholder engagement by having a deeper engagement of the community in engineering teaching and learning. Thus, the project modified “who gets to play” in the engineering space.

The CBO thanks you for the poster you presented.... However, the poster session also made the community aware of two other issues that could potentially impact on the success of the project. The first is the cost of the storage vessels for the biogas and biomethane.... The second is the safety considerations associated with the handling and storage of biomethane.... Thus, the CBO would like your team to investigate and report on the storage and safety issues. (Project Task)

As the above excerpt exemplifies, the community as actualized through this project was not just passive. Rather, the community directed the work of students (in the role of engineering consultants) based on their own needs and the available resources.

Finally, the project provided an opportunity to critique the existing canons of engineering knowledge. As students were working on this small-scale community-focused project, they realized that the resources (i.e., textbook or the internet) available to them to solve the given problem inadequate. As the course lecturer reflected:

Because the plant was so much smaller than if it had been an industrial plant, all of the wonderful heuristics that are used were out of range.... And so indeed there’s a vacuum of engineering methods at community scale work. And that’s an important finding actually of this piece of work.

This finding calls for expanding the scope of engineering knowledge to include concepts and heuristics that can be applied to small-scale community driven projects.

* 1. Case Study 3: Building and Sustaining Diverse and Inclusive Teams

**Background** In 2009, the American Society for Engineering Education (ASEE) assembled a task force aimed to create a strategic plan to increase diversity in engineering through various activities and policy changes [34]. Since then, the taskforce has evolved into a volunteer-led commission called the Commission on Diversity, Equity, and Inclusion (CDEI). The commission comprises six committees and five teams dedicated to advancing diversity, equity, and inclusion across the varied professional interests within the national engineering education association. The committees include Awards, Communications, Conference Planning, Policy and Letters, Professional Development, and Strategic Planning and Assessment. The teams include Spotlight, Outreach, Institutional Change, Encouragement, and Community Building. While it may be interesting to reveal the strategies and challenges associated with building and sustaining a dynamic infrastructure responsive to the emerging issues plaguing our institutions and society, as a commission, this case study is based on a diverse team of engineering educators that advanced from the Virtual Workshop team to championing the Professional Development Committee. Above all, this team was selected as the basis of a case focused on diverse and inclusive working environments due to the commitment and growth of a volunteer-driven team for four consecutive years.

Before the pandemic, the executive leadership for CDEI decided to expand the professional development program to include virtual learning opportunities for the ASEE community that extend beyond the lifecycle of the annual conference held in June. As a result, the virtual workshop team was established to operate as a sub-team of the professional development committee. In Spring 2020, right on the cusp of the Coronavirus outbreak, we facilitated the first virtual workshop, “Engineers Show Up: Let’s Talk about Allyship,” with approximately 20 participants, primarily in response and support of a campaign to Show up and Disrupt in engineering education through a week of action [35], [36]. Drawing from lessons learned gained from the transition to the virtual conference and virtual workshops and discussions held during the summer, we launched the Focus Fridays series in Fall 2020. This series is a virtual learning program for engineering education professionals specifically designed to offer the engineering education community an opportunity to translate their work into interactive virtual workshops to encourage professional development beyond the annual conference. Most importantly, we aim to promote sessions that provide participants with knowledge and skills readily applicable to their teaching, research, and leadership. Within six months of establishing the virtual workshop team, our team expanded from two to six dedicated members who are trained to review proposals and support facilitators from acceptance to implementation.

To date, our team has nearly doubled within the past four years. It includes eight women and one man representing nine universities in the US across multiple functions in the engineering education ecosystem (e.g., graduate student, postdoctoral research associate, engineering collections and research analyst, assistant professor, diversity or broadening participation in STEM office director, research manager, and learning scientist). Over time, the Focus Fridays series has grown to offer 15 virtual workshops and three panels, impacting nearly 725 participants collectively across the sessions and panels. These virtual workshops cover various topics to ensure our community is equipped with the knowledge and skills to support the diversity, equity, and inclusion of marginalized or historically excluded groups in engineering. For example, as a community, we have discussed latent diversity, culturally relevant pedagogy, advancement of women in STEM, positionality statements, accessibility for faculty with disabilities, microaggressions, parenting during the pandemic, contemplative pedagogies, and inclusive leadership. Likewise, our panels have discussed the experiences of graduate students who identify as LGBTQ+ and the mental health of Black graduate students and faculty.

Most importantly, our facilitators represent a combination of faculty, student support staff, graduate students, administrators, and practitioners. As we have transitioned to lead and support the professional development (PD) committee, we lead the coordination and execution of in-person professional development programming for the national annual conference, the Focus Fridays virtual series, and Distinguished Topical Plenary Speaker. On par with the impact of the previous PD committee, we coordinated the logistics of 15 PD sessions offered at the 2023 annual conference in Baltimore, MD. These sessions focused on decolonization, cultural change, equity audits, harassment in work and school, stewardship over gatekeeping, and critical mentorship in engineering education.

We have built and sustained inclusive relationships and practices through transparency, accountability, communication, respect, support, and care. For example, outside the realm of the commission, we have also supported one another during various life experiences and milestones, such as dissertations, career transitions, and other life events. In addition, we provide space in our bi-weekly meetings to share various updates and exciting projects we are leading and contributing to in our respective positions. Notably, we cherish and protect the working environment we have created where everyone feels valued and heard.

As an inclusive leader, providing a supportive and responsive environment and leveraging the team’s expertise is important, considering the leader does not know everything. Another key element is the intentional practice of shared responsibility. As the team’s demands grew, we implemented a team structure encompassing multiple roles to accommodate our expanding submission requirements and community responsibility. These roles include assessment and evaluation specialists, digital communications specialists, reviewer specialists, and resource specialists. This work also involves championing the development of new processes to ensure we practice what we recommend regarding how we select proposals, panelists, and distinguished speakers. Together, we contribute to the overarching mission and strategic efforts of CDEI, recognizing that we all play a vital role in our respective positions.

Our central dilemma influencing our operation involves the reality of limited resources, which has substantial implications for the individuals and teams willing to share their insights in virtual and in-person formats. Likewise, as a byproduct of the limited resources, we could not provide our distinguished speaker with an honorarium and understand how soliciting an unpaid speaking engagement (re)produces inequities and are seeking ways to rectify this prevailing issue. However, we have received financial assistance (e.g., external donors and registration waivers) to support some program costs. Above all, we use insights to build inclusive systems to inform how we provide a platform for ourselves and others to advance diversity, equity, and inclusion in engineering education.

1. Discussion, Challenges, and Connections

Throughout the literature review and case studies, we have observed certain commonalities. In the FemTech and Decolonization topics, we see the use of project-based learning to facilitate the integration of DEI concepts into engineering education, and empowering students to form and validate their own engineering identities through ownership and relatable contexts, and for staff to share their own experiences. This strength in identity is also seen in our third case study, where the team is encouraged to work in specialist roles and sit within an environment where life experiences are shared and supported. This positioning of personal identity and ‘otherness’ as a strength enables the creation of welcoming environments and a sense of belonging, and the democratization of knowledge and skills.

Nevertheless, all this positive power of DEI work does not come easily. Within the case studies, we have identified multiple constraints imposed on the leaders, such as time, workload, and financial constraints, which ultimately limit the speed, quantity, and quality of progress made. All case studies also found that their work revealed knowledge gaps within the current system, which must be addressed for projects to proceed to the desired depths.

The shared experience of marginalized groups enables them to join in supporting one another, sharing knowledge and expertise, and addressing some of the gaps and workload issues raised above. However, it must also be noted that it cannot be assumed that all marginalized groups have the same experience, nor every individual within a marginalized group. Thus, the need to adapt solutions to local or even individual contexts is key, requiring DEI advocates to be simultaneously an international and a decentralized resource [27] [37]. This approach requires sufficient staff time, resources, and awareness of international networks, and opportunities to engage in local activism and research.

While academic staff, DEI advocates, and empowered students are a hugely valuable resource in creating inclusive learning and working environments, it is important to recognize that those people will not have a lived experience of all marginalized characteristics and that inclusion goes beyond visible issues. Many reasons for exclusion, such as disabilities or difficulties, sexuality, or socio-economic background, cannot be seen. As we develop curricula and professional development platforms, considerations must be taken to ensure that engineering educators are equipped with the knowledge and skills to prevent or mitigate experiences that further reinforce marginalization and exclusion. To achieve this, we must, as this chapter has reinforced, focus on creating environments where people can recognize their experiences as having value, and from there, we can co-create projects and platforms to enable change through a diverse lens.

1. Recommendations

The three cases discussed in this chapter highlight how fostering diversity and inclusivity is possible at both the curricular and the organizational levels. However, the first step to this process is to reflect on who is marginalized and how they are marginalized within a given context. For example, the FemTech and the decolonization cases demonstrate how the engineering curriculum and culture can support marginalized students. Hence, it is important for stakeholders (e.g., faculty, staff, and administrators) across the engineering education ecosystem to critically evaluate who is represented and who is excluded while thinking about how to build and sustain diverse and inclusive learning environments for engineers [38]. For example, while a project focused on teaching students industrial processes and ways to enhance corporate financial gains is helpful for future employment, it may alienate several students, especially those who struggle to relate to the project context or are not represented as potential beneficiaries.

Integrating socially and locally relevant problems in engineering curricula and course design should not be considered an either-or debate. We acknowledge that industrial systems and manufacturing are necessary in the modern world to support the needs of people worldwide. Instead, the suggestion here is to incorporate curricular elements that make engineering more relatable for students while challenging the scope of engineering knowledge and work.

While it is important to design engineering curricula inclusive of different student backgrounds and epistemic traditions, we must also provide institutional support to individuals seeking to learn how to integrate diversity, equity, and inclusion in their work. The ASEE Commission on Diversity, Equity, and Inclusion initiative is an example in this direction, where their committee can be used as a vehicle to amplify practical examples of creating inclusive learning and working environments through various pedagogical and structural innovations, like the examples presented in this chapter.

The following recommendations reinforce case study insights and other scholars and practices in engineering education.

* **Recommendation #1:** Use intersectional and comprehensive approaches to identify the students’ needs and leverage their interests and community needs to design meaningful learning experiences
* **Recommendation #2:** Allocate resources (e.g., time, funding, and people) necessary to adequately address issues concerning diversity, equity, and inclusion in the learning and working environment
* **Recommendation #3:** Intentionally collaborate with local stakeholders and national and international practitioners to develop best practice appropriate to your context
* **Recommendation # 4:** Invest in continual learning and recognize that no one individual is the expert on all elements of diversity, equity, and inclusion

Lastly, we recognize the constraints some individuals and organizations may have considering the federal and state anti-DEI legislation in the USA context and others. This reality may influence your ability to adapt some of the recommendations presented throughout this chapter.

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References

[1] A. Tapia and A. Polonskaia, *The 5 Disciplines of Inclusive Leaders : Unleashing the Power of All of Us*. Oakland: Berrett-Koehler Publishers, Incorporated, 2020.

[2] V. Sellers and I. Villanueva Alarcón, “From Message to Strategy: A Pathways Approach to Characterize the Hidden Curriculum in Engineering Education”, Studies in Engineering, vol. 4, no. 2, p. 176–200, 2023.DOI: https://doi.org/10.21061/see.113

[3] D. A. Delaine, D. Williams, R. Sigamoney, and R. Tull, “Global Diversity and Inclusion in Engineering Education: Developing Platforms toward Global Alignment.,” *Int. J. Eng. Pedagogy*, vol. 6, no. 1, 2016.

[4] J. M. Williamson, J. W. Lounsbury, and L. D. Han, “Key personality traits of engineers for innovation and technology development,” *J. Eng. Technol. Manag.*, vol. 30, no. 2, pp. 157–168, 2013.

[5] S. A. Male and D. Bennett, “Threshold concepts in undergraduate engineering: Exploring engineering roles and value of learning,” *Australas. J. Eng. Educ.*, vol. 20, no. 1, pp. 59–69, 2015.

[6] C. McMillan, “Monitoring Female Fertility Through ‘Femtech’: The Need for a Whole-System Approach to Regulation,” *Med. Law Rev.*, vol. 30, no. 3, pp. 410–433, 2022.

[7] C. C. Perez, *Invisible women: Data bias in a world designed for men*. Abrams, 2019.

[8] T. Almeida, M. Balaam, and R. Comber, “Woman-centered design through humanity, activism, and inclusion,” *ACM Trans. Comput.-Hum. Interact. TOCHI*, vol. 27, no. 4, pp. 1–30, 2020.

[9] R. Grosfoguel, “The epistemic decolonial turn: Beyond political-economy paradigms,” *Cult. Stud.*, vol. 21, no. 2–3, pp. 211–223, 2007.

[10] N. Maldonado-Torres, “On the coloniality of being: Contributions to the development of a concept,” *Cult. Stud.*, vol. 21, no. 2–3, pp. 240–270, 2007.

[11] L. T. Smith, *Decolonizing methodologies: Research and indigenous peoples*, 3rd ed. Zed Books, 2021.

[12] W. Mignolo, *The darker side of western modernity: Global futures, decolonial options*. Duke University Press, 2011.

[13] A. J. Mbembe, “Decolonizing the university: New directions,” *Arts Humanit. High. Educ.*, vol. 15, no. 1, pp. 29–45, 2016.

[14] CHE, “Decolonising the curriculum: Stimulating debate,” *Briefly Speaking*, vol. 3, 2017.

[15] D. Riley, A. L. Pawley, J. Tucker, and G. D. Catalano, “Feminisms in engineering education: Transformative possibilities,” *NWSA J.*, vol. 21, no. 2, pp. 21–40, 2009.

[16] C. Soudien, “The Learning Challenge in South African Higher Education,” in *Transforming Universities in South Africa*, Brill, 2020, pp. 131–155.

[17] B. Dube, “Afrikaans must fall and English must rise-ironies and contradictions in protests by South African university students,” *Afr. Insight*, vol. 47, no. 2, pp. 13–27, 2017.

[18] S. Motala, Y. Sayed, and T. de Kock, “Epistemic decolonisation in reconstituting higher education pedagogy in South Africa: the student perspective,” *Teach. High. Educ.*, vol. 26, no. 7–8, pp. 1002–1018, 2021.

[19] R. D. Bugher, “Historians in Professional Associations,” *Public Hist.*, vol. 5, no. 3, pp. 77–83, 1983.

[20] G. M. Leibnitz *et al.*, “The inclusive professional framework for societies: Changing mental models to promote diverse, equitable, and inclusive STEM systems change,” *Front. Sociol.*, vol. 6, p. 784399, 2022.

[21] E. Marín-Spiotta, “Harassment should count as scientific misconduct,” *Nature*, vol. 557, no. 7706, pp. 141–142, 2018.

[22] T. F. Madzima and G. C. MacIntosh, “Equity, diversity, and inclusion efforts in professional societies: intention versus reaction,” *Plant Cell*, vol. 33, no. 10, pp. 3189–3193, 2021.

[23] J. Silverstein, “The Global Impact of George Floyd: How Black Lives Matter Protests Shaped Movements around the World,” *CBS News*, Jun. 04, 2021. https://www.cbsnews.com/news/george-floyd-black-lives-matter-impact/

[24] T. Smith-Jackson, R. Pak, K. Johnson, A. McLaughlin, and E. Rovira, “The HFES Diversity Task Force: Advancing the HFES Vision of Inclusion,” in *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, SAGE Publications Sage CA: Los Angeles, CA, 2016, pp. 422–424.

[25] V. A. Segarra *et al.*, “Scientific societies advancing STEM workforce diversity: lessons and outcomes from the Minorities Affairs Committee of the American Society for Cell Biology,” *J. Microbiol. Biol. Educ.*, vol. 21, no. 1, pp. 10–1128, 2020.

[26] American Society for Engineering Education, “WHAT’S THE DIFFERENCE BETWEEN AN ASEE DIVISION AND COMMISSION?” [Online]. Available: <https://diversity.asee.org/deicommittee/2023/05/12/whats-the-difference-between-an-asee-division-and-commission/>

[27] E. M. Holcombe, J. Paul, A. J. Kezar, and D. Vigil, “Organizing Shared Approaches to Equity Work,” *The Journal of Higher Education*, pp. 1–29, Feb. 2024, doi: https://doi.org/10.1080/00221546.2024.2301913.

[28] V. R. Morris and T. M. Washington, “The role of professional societies in STEM diversity,” *Am Math Soc*, vol. 65, 2017.

[29] T. Krishnamurti, M. Birru Talabi, L. S. Callegari, T. M. Kazmerski, and S. Borrero, “A framework for Femtech: guiding principles for developing digital reproductive health tools in the United States,” *J. Med. Internet Res.*, vol. 24, no. 4, p. e36338, 2022.

[30] O. Koopman, “Is the decolonisation of the South African university curriculum possible in a neoliberal culture?,” *Alternation*, vol. 24, pp. 48–69, 2019.

[31] A. Agrawal, H. Heydenrych, J. M. Case, F. A. Guni, and S. Brown, “Leaving the 20th century behind: Exploring how a community-focused design project responds to the call for decolonising an engineering curriculum,” presented at the South African Chemical Engineering Congress Virtual Conference, 2021, pp. 361–370.

[32] A. Agrawal, H. Heydenrych, and G. Harding, “Application of a decolonisation framework to a second-year chemical engineering design project,” *South. J. Eng. Educ.*, vol. 1, pp. 39–60, 2022.

[33] S. Mathews, “Asset-based, community-driven development (ABCD) in South Africa: Rebuilding communities from the inside out,” presented at the 4th Annual Soweto Conference, Centre for Small Business Development Conference, University of Johannesburg, 2013.

[34] American Society for Engineering Education, “Engaging a Community in Diversity, Advocacy, and Inclusive Practices.” [Online]. Available: <https://diversity.asee.org/deicommittee/>

[35] E. Foster and D. M. Riley, “Campaign Among Engineering Educators,” in *2020 ASEE Virtual Annual Conference Content Access*, 2020.

[36] D. Riley, E. K. Foster, and J. Karlin, “Show up and disrupt,” *Journal of Engineering Education*, vol. 109, no. 1. Wiley Online Library, pp. 7–10, 2020.

[37] A. Kezar, P. Eckel, M. Contreras-McGavin, and S. J. Quaye, “Creating a web of support: an important leadership strategy for advancing campus diversity,” *Higher Education*, vol. 55, no. 1, pp. 69–92, Jun. 2007, doi: https://doi.org/10.1007/s10734-007-9068-2.

[38] A. L. Pawley, “Shifting the ‘default’: The case for making diversity the expected condition for engineering education and making whiteness and maleness visible,” *J. Eng. Educ.*, vol. 106, no. 4, pp. 531–533, 2017.

