A Scoping Review of Diversity, Equity, and Inclusion in Energy Engineering Education

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Abstract
A diversity, equity, and inclusion (DEI) problem persists in undergraduate programming, despite energy engineering receiving increasing attention as a critical field in addressing sustainability and global energy challenges. This paper examines the current situation of energy engineering education on DEI worldwide based on the areas of gender, race, and socioeconomic inclusion. This discussion examines the challenges and explores inclusive pedagogy, curriculum structure, faculty development, student mentoring, and institutional commitment. The review concludes that, although some of these initiatives are promising, integration is cursory and inconsistent. Embedding DEI in teaching pedagogy, institutional frameworks, and policy to enhance the undergraduate students' learning outcomes and equity in energy engineering is recommended.

Keywords: Energy Engineering, Diversity, Equity, Inclusion, Engineering education.

Introduction

Engineering education has come to acknowledge that learning in all its forms can be enhanced through diversity of talent and inclusive learning environments as being crucial in innovation and societal advancement. The purpose of Equity, Diversity, and Inclusion (DEI) initiatives is to eliminate structural inequalities, which have hampered the ability of women and racial/ethnic minorities, along with low-socioeconomic-status (SES) students, to pursue engineering in the past (Amer et al., 2024; Direito et al., 2021). Identities are usually defined in terms of DEI as the presence of diverse identities (race, gender, culture, etc.) and a set of institutional practices that guarantee equitable access (equity) or a sense of belonging (inclusion) (Direito et al., 2021). Diverse teams have been shown to increase creativity and innovation in engineering; however, there remains a leaky pipeline, where certain groups still leave the programs or careers out of proportion regarding undergraduate groups (Ridgway et al., 2023; Smith et al., 2023). Energy engineering is a sub-discipline of engineering that lies on the borders of technology, the environment, and society, and thus, should represent the multiplicity of people all over the world. Lying at the crossroads of mechanical, electrical, chemical, and environmental engineering, energy engineering is aimed at developing, integrating, and optimizing energy systems, such as renewable energy, energy efficiency, power generation, and energy storage (Thumann & Mehta, 2020). Therefore, it is central in regard to net-zero ambitions, decarbonization, and energy access equity around the world. In spite of the significance, the deficit in representation is still notable, especially when it comes to gender, racial or ethnic minorities, and students of disadvantaged socioeconomic statuses. Creativity, equity, and inclusion in energy engineering education are valid as diversity encourages the generation of new ideas, equity maintains a fair involvement, and inclusion maintains engagement, but their practices are still uneven (Pellissier et al., 2022). The restricted representation of women, minorities of color, and students of low socioeconomic status decreases the level of diversity and innovation in intricate energy

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issues (Stephens, 2020). The effects of energy transitions vary when this happens across communities; hence, a diversified workforce in energy engineering must exist to establish inclusive and sustainable solutions. This review examines the global strategies to promote DEI in undergraduate energy engineering education. The issues concerning gender, race/ethnicity, and SES were discussed. Also, gather information related to pedagogical strategies, curricular improvement, and policies that have taken place across the globe.

Methodology

The scoping review has been carried out with the use of academic databases (Scopus, Web of Science, Google Scholar) and the reports of professional bodies dated between 2010 and 2024 (Amer et al., 2024). The searching keywords included "diversity", "equity", "inclusion", "energy engineering," and "undergraduate groups in STEM," with a specific focus on energy engineering, gender, race, and socioeconomic status. Amer et al. (2024). Amer et al. (2024) gave an example of how the systematic keyword searching (equity, diversity, engineering education) and thematic analysis of DEI in engineering faculties could be performed (Smith et al., 2023). Documents were chosen on the basis of their relevance to undergraduate energy engineering and their inclusion of DEI themes. There were 42 sources examined in the review, which include journal articles (20), conference papers (7), governmental reports (4), institutional policy reports (5), books and book chapters (4) and dissertations (2). A qualitative thematic analysis was conducted by reviewing each selected source systematically and identifying recurrent themes around topics pursued for diversity, equity and inclusion in energy engineering education. The articles were reviewed in detail, and prominent observations pertaining to sex, race/ethnicity, or socioeconomic status were recorded. Words with similar ideas were then grouped together, and patterns in the literature were compared to ascertain common themes. This recursive process permitted the identification of larger, thematic categories to emerge from among the analysed sources, which allowed for a structured review of DEI concerns and practices in the field.

DEI in Energy Engineering Education

DEI in energy engineering education is identified into several categories. Diversity consists of the representation of identity (gender, race, socioeconomic status, ability, and culture) (Fernández et al., 2023). Equity addresses the barriers that keep individuals in an unfair situation by allowing inclusion in the learning environment that makes individuals feel appreciated and welcomed (Ainscow, 2020). These principles are critical in the development of solutions in energy engineering that are socially just, technically, and culturally responsive. The energy engineering field of study has an immense scope of disciplines and technologies that are essential to the creation of a sustainable future. They consist of a clean energy system like solar, wind, hydro, and biomass, intelligent electrical grids, and efficient building and industrial energy systems, carbon capture and utilization and storage (CCUS), and emerging technologies such as hydrogen energy and the advanced nuclear system (Thumann & Mehta, 2020). The technical, social, and international nature of these fields requires a skilled and socially responsible workforce.

University of Toronto has started to incorporate Indigenous knowledge as well as environmental justice in energy systems design curricula (*Integrating Indigenous Perspectives into the UC Curricula,* 2025; Kanu, 2011). Electrical and information engineering technology (EIET) program at the University of Northern Iowa (UNI) is incorporating social equity aspects into college-level capstone projects in renewable energy, where they would encourage students to design technologies that would consider an environmental and social payoff (Pecen et al., 2003). United States TRIO and LSAMP programs are federal initiatives that subsidize, mentor, and provide undergraduate students in STEM and energy access to research opportunities (Donovan et al., 2021). These programs have enjoyed great success when it comes to the low-income, first-generation, and minority students. African Centre of Excellence in Energy for Sustainable Development (ACE-ESD) in Rwanda is an example of inclusive energy education regionally in Africa (Khundi-Mkomba et al., 2021). The center attracts both academic excellence and social responsibility through its gender balance targets and interaction with the immediate communities.

The practitioners in this sector should be capable of traversing the vicinity of energy technology, environmental impact, and the overall welfare of society. Therefore, DEI is fundamental in the process of energy engineering education because it ensures that students across the board can engage, join, and contribute to the resolution of energy problems through incessant creation. A multicultural classroom environment adds texture to classroom discussions and promotes teamwork, as well as increasing the insights into social aspects of engineering solutions (Akintayo et al., 2024). This subsequently translates to more efficient energy systems, which are fair and fulfill the requirements of various populations.

Gender Equity

Gender imbalance remains stark in energy-related engineering programs globally. In most jurisdictions, less than one-third of the engineering graduates are female (Ali et al., 2025; Krishnannair & Krishnannair, 2024). In Sub-Saharan Africa (SSA), less than 30 percent of tertiary engineering graduates are female (Obonyo, 2024), for example. This male-dominated culture promotes stereotyping about the ideal engineer and helps in the attrition of women (Baird, 2018; Smith et al., 2023). To deal with this, curbing measures have been implemented by institutions and governments. In India, since 2018, a supernumerary reservation (quota) of 20 % female students in top institutes (Indian Institutes of Technology and National Institutes of Technology) has been added to their current 14 % reservation (Choudhury, 2016). A number of state and privately owned colleges in India, too, have reservations of 5 to 33 % of the seats for women, and the All India Council for Technical Education has given 10,000 Pragati scholarships to girl students in engineering every year (Das, 2025). Such policies succeeded in increasing the number of women enrolled in colleges somewhat (e.g. the female share in Indian Institutes of Technology increased to ~20% versus 8% before) (Das, 2025). Pragati scheme has been introduced to provide scholarships and reserved seats for girl students in technical disciplines such as energy engineering with the support of All India Council for Technical Education (AICTE) (Priyadarshini & Latha, 2019). The results of such efforts are reflected as there are now observed more women venturing into institutions of excellence like the Indian Institutes of Technology (IITs).Top-down policies of this type are seen elsewhere (e.g. quotas of women in Brazil, which are not described here).

Beyond admissions, universities build support structures. Inclusive policy is established through dedicated diversity offices or committees (e.g. the Engineering Equity, Diversity, Inclusion, & Decolonization steering committee at Western University (Amer et al., 2024)), and community is fostered through campus networks (e.g. chapter-based women-in-engineering, mentoring circles). In Spain, the 54 universities in Spanish Universities for University Excellence (RUIGEU) network of Gender Equity Units established it as a way to communicate and exchange best practices to increase the success of women (Amer et al., 2024). Spain has implemented the RUIGEU network that brings together gender equity offices at over 50 universities, providing a platform where DEI policies are developed and implemented in a consistent manner. Action plans and targets can assist as well: e.g. some faculties are now monitoring gender disparities in enrolment/retention and establishing targets they want to achieve. In the classroom, inclusive pedagogy supports women's success. Some of these strategies are active-learning strategies (which empirically reduce gender gaps in performance), teaching methods that involve the Universal Design for Learning to address various needs of students, and incorporating topics about female engineers and gender issues into the courses (Witcher, 2020). As an example, culturally-responsive curriculum could emphasize the work of female engineers or include gender biases in case studies, thus enhancing relevance and belonging in women students (Lux et al., 2024).

Racial and Ethnic Diversity

Students who are undergraduate ethnic/racial minorities usually face more challenges in engineering studies. According to U.S. research, programs "are less likely to retain women and students of color at all levels". The stereotypes and microaggressions against the identities of minority students may undermine self-efficacy and the sense of belonging among them. Latine and Black engineering students, as an example, state that they feel like outsiders in white-dominated programs. In addition, minority students are overrepresented as low-income students (e.g. many Latinx students have low-income families), thereby adding to access challenges (Smith et al., 2023).

Institutions combat these challenges through targeted recruitment and support. The outreach programs collaborate with a high school in the underserved communities to motivate minority youth. As an example, the U.S. universities are involved in such programs as TRIO Talent Search and Upward Bound that select low-income, first-generation, Science, Technology, Engineering, and Mathematics (STEM) talent and offer them college-preparatory experiences. These programs are connected with engineering camps and mentorship, such that one student recalled that a TRIO mentor showed her around aerospace labs and discussed scholarship options, which in effect builds technical capital and demystifies college engineering (Martin et al., 2020). Pathways to entry (e.g., link or foundation years, or higher offers to undergraduate groups) are also used in many schools to admit minority students as well as to provide bridging courses as part of the solution to the lack of preparation.

Institutional action plans and affinity groups are common on campus. Peer support and professional development opportunities in engineering are common in North American engineering schools through the presence of chapters of NSBE (National Society of Black Engineers), Society of Hispanic Professional Engineers (SHPE), and American Indian Science and Engineering Society (AISES), among others. Other faculties use the appointment of EDI champions or committees to direct efforts against racism. As an example, the Faculty of Engineering of McGill University developed an Action Plan Against Anti-Black Racism, some of the goals of which include expanding the presence of Black students and diversifying its faculty. Another model is the government-led approach of Spain, where the country has national networks of universities (e.g. Conference of Rectors of the Spanish Universities (CRUE)-Diversity and Disability of CRUE-Students Affairs) that coordinate disability and diversity policies in 66 universities, and a Network for Diversity (RUD) comprises 30 universities that explicitly proclaim to promote inclusion of sexual/gender diversity, cultural and religious backgrounds, etc. (Amer et al., 2024). Such networks support the exchange of policies (e.g., anti-discrimination training, inclusive facilities) and allow universities to teach one another.

Canadian universities use decentralized action together with specific plans. According to Amer et al. (2024), numerous engineering institutions have their equity programme. As an illustration, McMaster University has developed a Faculty of Engineering Equity Plan and McGills above-mentioned anti-racism plan. McGill University (Canada) is one example that has implemented an anti-Black racism action plan in the Faculty of Engineering, which includes the review of hiring practices, curricula change, and collaboration with local communities (Burke et al., 2021). In Spain, the national policy, on the other hand, secures harmonization of efforts. These are two varying models that run in context: Canadian higher education is institution-centered, whereas the Spanish system can have government-funded and nationwide programme. The lesson is that bottom-up (institution-led) approaches, as well as top-down (policy-driven) approaches, can promote racial inclusion when coordinated with the local needs.

Socioeconomic Inclusion

There are unique challenges that confront low-income or first-generation college engineering students with respect to energy engineering. Quite a number arrive unprepared because of unequal K-12 resources (Smith et al., 2016). Especially math-intensive and rigorous, engineering programs can leave unprepared students struggling (Kopparla, 2019). Tuition and living costs are another cause of financial stress that prevents persistence. Numerous schools provide financial support to STEM students, specifically on a need-based basis. The above-mentioned Pragati scheme in India provides the scholars with scholarships for girls (Priyadarshini & Latha, 2019). In some countries, there exist stipend programs for low socio-economic status STEM students (Baldwin et al., 2022). In Canada, the U.S., and elsewhere, grants (e.g., Pell Grants, NSERC bursaries) and programs (TRIO Student Support Services) for disadvantaged students are funded by governments (Diehl, 2024; Grants, 2019). Canadian Scholarship for Persons with Disabilities (CSEP) scholarships and Engineers Canada scholarships typically have lower-income candidates who are underrepresented as their target audience (Harrison & McCarron, 2023; Ross et al., 2020). Engineering cohorts of disadvantaged backgrounds are also financed by nonprofits and industry foundations. On analyzing Southern Africa, a UNESCO survey suggested both campaigning and funding (stipends, scholarships) to increase female numbers in STEM (Unterhalter et al., 2024).

Many effective interventions on all levels of DEI are supported by inclusive classroom teaching and teaching according to the relevant curricula. Extensive research on engineering education demonstrates that the student-centered, active-learning method has multiple advantages, including the disproportionate benefits to the underrepresented learners. To clarify, a meta-study investigating the effects of high-quality active learning concluded that the high-quality active learning decreased the gap in exam scores between majority and minoritized students majoring in STEM by approximately 33% and in passing rates by approximately 45% (Witcher, 2020). This has been aligned to an active-learning inclusive approach, and the fact that active-learning depends on scaffolded practices, regular feedback, and group interaction, and does not condescend to the students (Witcher, 2020). Energy engineering courses, therefore, where the primary teaching tool is experiential (hands-on projects, small group problem solving, and peer instruction), enable minority, female, and lower-SES students to close the gap and feel appreciated. Instructors would be advised to use Universal Design for Learning (UDL) principles (Lux et al., 2024), including providing more than one presentation of material (visual, verbal, collaborative); delivering low-stakes forms of assessment; and creating a classroom environment that shows belonging.

DEI is also facilitated through reforms in the curricular content. Incorporating issues of energy that are germane to a variety of communities (e.g., rural electrification or the gendered effects of energy policy) can be used to engage students with a variety of backgrounds. Assignments and case studies designed to profile the contributions inflicted by engineers of color and women broaden layer models. Units on ethics and social justice in engineering (requiring DEI and global development modules) raise all students to the level of consciousness of equity issues. As an example, there exists a teaching module that provides engineering people with an introduction to the concept of the ethics of diversity and inclusion (Sabat, 2023). Some institutions provide clear teaching regarding implicit bias, how to cooperate in multidisciplinary teams, and the power of diversity (Diaz et al., 2020). All these curricular strands are indications of institutional good intentions and provide students who are underrepresented with a sense that their identities are applicable to the engineering task.

Faculty development is also very important. Classroom climate may be improved by training and preparing instructors in inclusive pedagogy, e.g. how to prevent disrespectful collaboration, express clear and encouraging language, or include inclusive examples (Dessel, 2010). Workshops on inclusive teaching and other resources are currently provided by engineering education communities (American Society for Engineering Education (ASEE) and the European Society for Engineering Education (SEFI)) (Direito et al., 2021). A similar program allowed faculty to incorporate equity issues into STEM curriculum and was reported to have increased engagement rates in students (Desing & Clayton, 2025). In short, curriculum changes that focus on active, culturally relevant, and student-centered learning have some of the most empirical support in changing diversity outcomes (Lux et al., 2024).

Challenges in DEI

The minority group and women are still underrepresented among students and faculty. DEI material is seldom considered in the engineering courses, resulting in curriculum gaps. Skepticism of the DEI and institutional inertia still persists; thus, the institute is resistant to change. The majority of teachers have not been trained professionally with regard to inclusive pedagogy. A small number of programs employ indicators to examine DEI practices. Few of the energy engineering programs employ measurements to analyze DEI programs; thus, there is insufficient evaluation. Also, the majority of the strategies target DEI only with one dimension of either gender, race, or income, without acknowledging that identities intersect in complicated ways. This restricts how effective interventions and actions can be in relation to learners with multiple and overlapping forms of disadvantage.

Partly due to structure and culture, there are several structural and cultural issues that constrain DEI in energy engineering education. First, the area to this day experiences a major lack of representation of women, as well as racial and ethnic minorities and low-income students. The percentage of female engineering graduates throughout the world is not even at 20 percent, and this is even lower in the disciplines that major in energy. There are also other setbacks, including the lack of quality STEM education and role models, that minority students experience. The institutions lack the ability to collect and disaggregate data regarding demographics and experiences of students, hence it is hard to see whether progress is being achieved or not, and to adapt interventions accordingly.

The DEI measures that sometimes prove to be ineffective include integration of DEI into technical curriculum, which is there only to add to elective programs, but is not incorporated into the general curriculum. The majority of curricula are still aligned to technical content without paying much attention to the social and ethical aspects of energy systems. Other subjects like energy justice, gender effects of energy transitions, or the contribution of engineering in solving energy poverty are instead given the status of peripheral to the field. This disjoint causes weakness in the ability of the students to think through the societal implications of what they are undertaking.

Thirdly, it can be a significant barrier to DEI initiatives because of certain resistance in some institutions. Certain faculty and administrators might view DEI as politically excessive, or they believe it has nothing to do with technical learning. This opposition will be furthered by a lack of awareness and training of instructors in inclusive teaching. Scalability of mentorship and training programs is restricted by resource-related limitations, especially in institutions that do not have significant funds. Consequently, most DEI activities are either isolated, informal, or low-funded.

Strategies and Recommendations for DEI in Energy Engineering Education

The most promising way of enhancing DEI is to include the societal issues of social justice and ethical consideration in the energy engineering curricula. This incorporates case studies about marginalized communities that are affected by energy projects, an analysis of the distributional effects of energy policies, and the incorporation of Indigenous and local knowledge systems in the design considerations. Technical knowledge and human knowledge can be connected through courses in energy and society, or global energy justice, or ethics in energy engineering.

Another important strategy is active and inclusive pedagogy. The enhancement of outcomes regarding undergraduate energy engineering students has been revealed to foster pedagogical strategies based on problem-based learning, a flipped classroom, and group projects. Assignments need to be culturally related or based on the community to make students relate to the material in a better way. Lecturers are supposed to speak inclusively, accommodate different styles, and be flexible to the different needs and backgrounds of students (Vásquez et al., 2025).

Mentorship and support networks will play an important role in guiding the undergraduate students through energy engineering programs. Peers in the form of peer mentorship groups, industry mentorships, and/or affinity networks, i.e., Women in Renewable Energy (WIRE) or the National Society of Black Engineers (NSBE), can offer academic, professional, and emotional support (McPherson, 2024). Such networks can be further enhanced through the support of alumni and industry partners who can frame role models and career access into oil and gas occupations.

Inclusive learning environments need the development of their faculty and staff. Academic staff should be trained to become aware of implicit bias, learn to address diverse learners, and interact in a respectful manner with DEI issues. Institutions ought to also reward such inclusive teaching using prizes, grants, and promotion guidelines that consider the contributions made to DEI. Interdisciplinary relations and continuous professional development courses are areas that can contribute to the capacity of faculty to work with DEI (Impedovo et al., 2025). Inclusive environments have to be continuously supported in the long term by faculty training and mentorship infrastructure. They should also encourage community-building and visibility through student-led DEI events and activities that institutions should support.

Institutions have to declare DEI a priority at an institutional level. This can be done by carrying out strategic planning where measurable diversity objectives are established to recruit, retain, and graduate students. To build a pipeline of DEI leadership positions and offices could be created where Engineering faculties would organize those initiatives and progress, and would hold people accountable. The metrics of DEI also ought to be integrated into the assessment models of accrediting bodies like ABET and EUR-ACE, so that equity can become one of the educational quality standards (Adăscăliţei & Arădoaiei, 2019; Putman et al., 2024). The bodies awarding accreditation ought to call on programs to contain learning outcomes revolving around equity and inclusion. Curriculum developers ought to come up with open-access material that mirrors diverse opinions and experiences.

DEI principles should become the core of educating engineers in the energy sector. Engineering, social sciences, and humanities offer transdisciplinary opportunities to complement and even transform curricula and to lead to more comprehensive views of energy systems. The national and regional organizations of the DEIs should provide a standard DEI reporting platform that will ensure the benchmarking of the different performances and the exchange of best practices. These systems have the potential to guide more specific funding, policy decisions, and accountability to the public on DEI in the engineering education field.

Conclusion

Inclusion, equity, and diversity in undergraduate energy engineering education are set to require complex responses. Bringing diversity, equity, and inclusion to energy engineering education is not only the right thing to do but a practical one as well. Since energy systems define economies, ecosystems, and the general lifestyles, they need to be modelled and developed by professional individuals who reflect and perceive the differences in the global society. There are shared principles to be discovered, and proactive recruitment of underrepresented populations, inclusive teaching, financial and social assistance to students, and program responsibility for achieving equity are some of them. With stakeholders moving into convergence on sustainable development priorities, DEI in energy engineering education is not just a social responsibility but a technical one: It opens the full range of human creativity to the clean-energy transition and well beyond. A broader energy engineering education makes engineering more innovative, increases access to opportunities, and empowers students to meet the energy challenges of our era. Incorporating DEI as a component of curriculum, pedagogy, faculty development, and institutional policy, energy engineering programs will be able to graduate individuals who can be the technical experts and paragons of social responsibility in the clean energy transformation.

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Conflict of Interest

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